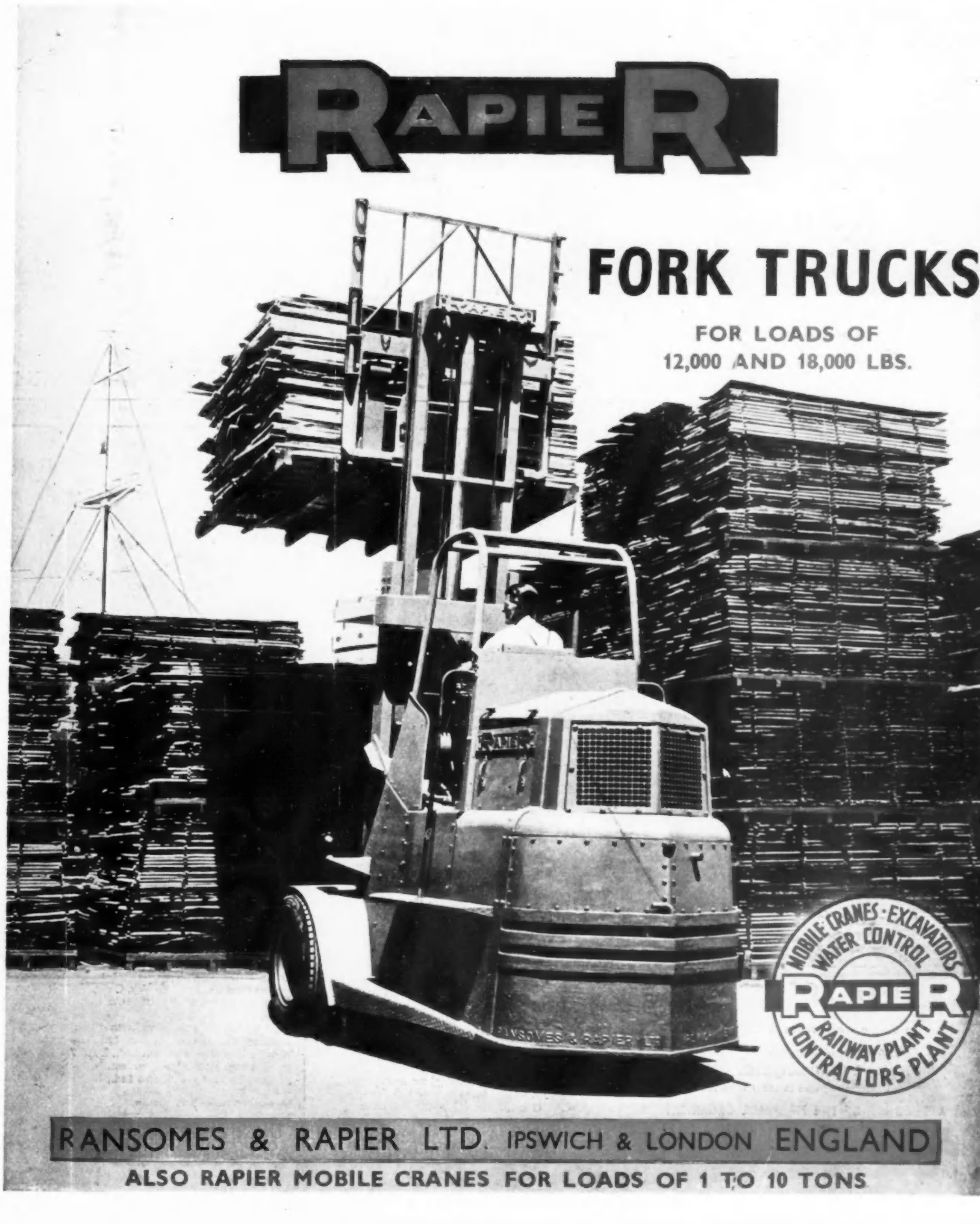
The Dock & Harbour Authority

No. 394. Vol. XXXIV. AUGUST, 1953 Monthly 2s. 0d.



The Dock & Harbour Authority

An International Journal with a circulation extending to 72 Maritime Countries

No. 394

Vol. XXXIV.

AUGUST, 1953

Monthly 2s. 0d.

Editorial Comments

The Port of Hamburg.

There are three important factors hampering the natural recovery of the maritime world to-day: they are briefly—flag discrimination, financial instability, and political restrictions. Whilst these matters are more directly related to shipowning interests, they have unfavourable repercussions on port administration and development programmes.

In the discussion of the recent " Baltic and International Conference of Shipping " at the Hague, the impression gathered was that of veiled pessimism, and this appears to be an echo of the current trend of opinion in maritime Germany. The article on the Port of Hamburg which will be found on a following page, gives a comprehensive sketch of the past and recent history of this city and sea port. It also touches upon the heavy programme for the future and voices the spirit of the Hamburgers in the struggle to regain some or all of the past prestige of the port. One feature compels attention—the author stresses the anxiety of the Hamburg State Administration to cement international friendship and goodwill. His description of Hamburg as an outpost of the Western World is certainly true in a democratic sense, as his remarks about labour conditions show.

However, there is a bright glimmer through the Hamburgian gloom: the speedy rate of rehabilitation of the damaged docks and the improvement of the port access since 1950 are distinctly promising for the future and reflect credit on the Administration and workers. In addition, there is great advantage in possessing a port almost fully equipped with the most modern appliances and structures, and here it should be pointed out that during the recent war the ports of the United Kingdom expended their substance and largely mortgaged their future to maintain that freedom which is essential to democratic well-being, with the result that they now have to struggle along under heavy financial burdens to keep up to date.

In a forthcoming issue of this Journal we hope to publish an article giving the technical details of the more notable rehabilitation works at the Port of Hamburg with examples of modifications of old installations to suit modern requirements, and of a technique peculiar to that port.

Nigerian Ports Authority.

In the last issue of this Journal, some space was devoted to the question of whether the operation of ports should be under the management of Railway Authorities or not. The subject is undoubtedly controversial, and there are many valid arguments, both for and against, which could be put forward concerning the control of the ports of East Africa and of the Union of South Africa by their respective Railway Administrations. It appears, however, that the present method of Railway control, now prevailing in those countries, will continue for some while to come.

It is interesting to learn, therefore, that in the case of the Crown Colony of Nigeria, it has been decided to separate the management of the ports from the railways and to constitute a Nigerian Ports Authority, under a Chairman who will also be the Chief Executive. A small Board of 10 members is proposed, and the payers of dues, both shipowners, and importers and exporters, are to be allowed to elect their own representatives, as is the case with autonomous Port Authorities in the United Kingdom and elsewhere. This will be an innovation as far as Nigerian Corporations and kindred organisations are concerned.

A brief description of the proposed Ports Authority will be found on a following page, and it will be observed that, initially, the new body will only be concerned with taking over the Government wharf activities in Lagos and Port Harcourt, although it will also, in due course, administer the other, incidentally much smaller ports.

The Ports Authority is also to take over the whole of the Marine Department, which at present covers many services (particularly in connection with the Inland Waterways) which are not functions of a Ports Authority and the cost of which it is inequitable to place against Port Revenues. The Government therefore will reimburse the Authority for all services carried out on its behalf and in the future and will give consideration to the establishment of a special Inland Waterways section within the Marine Department of the Ports Authority. This may become a separate Department of the Government when the development of the Inland Waterways of Nigeria, with their vast potential, justifies this step.

The outcome of these far-reaching decisions will be watched with the keenest interest, and we wish the Chairman and staff of the new Authority every success in their endeavours to increase efficiency in port management and operation.

Large Dry Docks.

In recent years the deficiency in the number of major dry docks in the United Kingdom has become increasingly apparent, mainly due to the construction of oil tankers of large dimensions. The matter was the subject of an article and of comment in the May issue of this Journal, and it is therefore with considerable interest that we learn that the Greenock Harbour Trust have submitted plans to the Admiralty, for a new dry dock capable of accommodating the largest ships now afloat or likely to be built for many years.

For 25 years or more all the large passenger ships built on the Clyde have had to be sent to Liverpool for dry-docking. During the last war a large floating dock was brought from Devonport to handle warships seeking safe anchorage in the Clyde, and to-day even oil tankers are becoming too large for the existing dry docking facilities in that area.

According to the plans submitted, the new dock will have a length of 1,200-ft., a width of 160-ft. and a depth of water over the sill at high water neap tides of 48-ft. The length would be equal to that of the King George V dry dock at Southampton, while the width and depth would exceed those of most of the world's dry docks. The proposals also include the widening and deepening of the present river channel and the provision of a fitting-out basin, while reclamation will bring the total area of land within the dock boundaries to about 25 acres.

The borings carried out by the Admiralty in 1946 showed that conditions favoured economic construction of a dock at the site selected, for a thick bed of clay exists over underlying grey sandstone rock. The dock floor and main walls will be of mass concrete gravity construction and although detailed estimates of cost have not yet been made, an assessment based upon costs of similar works

Editorial Comments—continued

elsewhere, and the very favourable Greenock site conditions, show that the whole project may involve an expenditure of between £3 million and £3½ million. It is estimated that the works could be completed in three years with an additional year for preparing plans.

Since the war, oil companies and other operators of tankers have proved to their satisfaction that very large vessels can be operated economically, and they expect others to provide facilities for their ships to be drydocked when they need repairs or periodical surveys.

For this purpose there are not many docks of the necessary size available, and although owners of dry docks must usually take cognisance of naval requirements for use during hostilities, government owned dry docks are not generally available for the mercantile marine in peace time. Neither are public docks, particularly those at terminal ports with ocean liner traffic and other commitments, generally available for long-term repair work on merchant ships.

The present situation, however, has not arisen suddenly, as some would aver, for it must be admitted that where privately owned docks are concerned, the position has remained practically static for many years, in spite of the appreciable increase in the size of ships. Undoubtedly the high cost of construction is a major cause and there is also the subsequent problem of full capacity occupation to be considered by dock owners. It is not surprising therefore that ship repairing firms owning dry docks should be inclined to be cautious in their deliberations on the problem.

With regard to initial cost and full capacity occupation aspects, we suggest that new lines of approach to the orthodox layout and construction of dry docks should be examined. In this respect the proposal made by Mr. Champness in the May issue of this Journal, has special grounds for expert consideration. Briefly, his proposal involves " a reorientation of the normal layout, square or oblique off the fairway, into one with the dock parallel to it." . . . This would give a " double-ended large dry dock design with variable position of one or more intermediate gates " . . . and " large variations in occupancy and flexibility."

Having regard to the importance of the subject, close collaboration between shipowners, dry dock owners and the Government would appear to be most desirable.

Further Re-organisation of British Transport.

Any announcement on the policy of the British Government about future plans for the British Transport Commission is welcome. The most recent statement in Parliament, two days before the Summer Recess, is not as precise as one would have liked, and members understandably complained about the continuing delay. However, although the Government declines to announce who will be appointed to fill vacancies on the Commission, or to give any detail of the re-organised system of operation, until it is possible to tell the country who is to succeed Lord Hurcomb, one point has been made clear: the several Executives, excepting only the London Transport Executive, are to be abolished. Since the 1947 Transport Act came into force, the nationalised ports and inland waterway undertakings have been directed by the Docks and Inland Waterways Executive, under the Transport Commission. This Executive is now to disappear, but certain officers of the Executive are likely to be appointed to appropriate positions at the Transport Commission Headquarters. If the transition can be effected rapidly, no great disturbance should result; the Divisional Waterways Officers, and the various Port Managers, who have in the circumstances directed their undertakings with admirable enterprise, will be able to continue their work without upset; if greater devolution of authority from the centre is really to be achieved, under the new regime, these officers may be able to do an even better job. However, there are certain matters which must be directed nationally rather than locally, and little time should be allowed to elapse before the new organisation is in being.

Recognition of the work of Lord Hurcomb, whose desire to resign as Chairman of the Commission has been known for some time, was expressed in Parliament, but this was rather overshadowed by the anxiety for information about his successor. Furthermore, until this is settled, nothing will be known about other appointments. We should regard it as a serious deficiency if there were not at least one member of the Commission with port experience, and one with considerable commercial experience in inland waterway matters. In addition there must presumably be a department at Commission Headquarters which will fulfil some of the functions hitherto the responsibility of the Executive.

We can, however, welcome wholeheartedly the explicit statement that there is no question of docks and inland waterways passing under railway control. We have as frequently drawn attention to the dangers of such domination, as we have to the future of canals of little commercial utility. In our view, the occasion of this transfer of authority to a body bound to regard the pattern of transport as a whole, presents an admirable opportunity to face the latter thorny problem.

Sea Pollution by Oil.

The report of the Committee appointed by the Ministry of Transport last October, under its chairman P. Faulkner, Esq., C.B., has appeared with commendable promptitude, and is the subject of an article on a later page, in which the Committee's summarised recommendations are reproduced. The deplorable and damaging effect of oil on the sea has rightly caused much public concern, especially on the issues of spoilage of beaches and damage to the amenities and welfare of coastal resorts, and of the distress and destruction of sea birds. This is a problem, a complete solution to which is only possible by international action, so that discharge of oily waste into the sea is almost entirely prohibited. This would involve the provision on board of oil separating plant, and the installation at ports of reception facilities. International agreements of the type envisaged must inevitably take time for negotiation, and preliminary discussions should be initiated with the least possible delay.

As the Committee advises, there is however no need to be content to wait the result of this international action. Great Britain has a tradition for imposing restrictions upon its citizens and its commercial undertakings, if these restrictions are morally justifiable and are likely to have some effect in expunging undesirable practices. We are also a sea-faring nation and one with an exceptional coastline. The hope, therefore, is that the Government will, as a first stage, introduce legislation to prohibit over a much wider area the discharge of oily wastes into the sea, by United Kingdom registered vessels. This will impose an additional burden, both upon British shipping interests, and upon dock and harbour authorities. The former would have to equip their ships with additional plant, and suffer a certain amount of operating inconvenience; for a time British ships alone would be faced with the consequent extra expense, but it is certain that British shipping companies, and especially owners of tankers, will not be slow in their response. In a statement issued by Mr. Donald Anderson, which followed immediately the publication of the report, the Council of the Chamber of Shipping of the United Kingdom announced the intention of its members, voluntarily and without waiting for legislation, to adopt the recommendations of the report to the fullest extent practicable.

Dock and Harbour authorities will need to provide reception facilities, and similar special facilities will be necessary at oil refinery terminals, oil loading ports and repair ports. There can be no doubt about co-operation on the part of these undertakings, especially since the oil companies and commercial oil-recovery firms have indicated their willingness to participate. It may well be that, by giving a lead to other countries on a problem which is essentially international, Great Britain will promote world-wide beneficial action. This is the way in which national prestige is built and maintained.

Development of the Port of Beira

It is reported from Mozambique that the expansion of the port facilities at Beira will be virtually completed by the end of this year, when the new wharf, built especially for the handling of export cargoes of chrome ore and other base minerals from the Rhodesias, will be in full commission. The new installations are now being tested and, when put into service, it is expected that the monthly exports of chrome ore and of copper from Rhodesia will be increased by at least 10,000 tons and 5,000 tons respectively.

The ores will be loaded from a jetty served by belt conveyors connecting with the dumping area. The jetty also carries pipelines running to the bulk oil installations so that tankers can berth there for discharge.

The great improvement in the port installations during the last four years is reflected by the fact that last year Beira handled a total of 2,600,000 tons of cargo which was 70% more than in 1948.

The Port of Hamburg

The History and Development of Town and Port

By ERNST PLATE
General Manager and Port Director.

"HAMBURG, Germany's Gateway to the world," this well-known slogan symbolises the proud result of more than a millennium full of hard work and never-resting efforts in the peaceful field of trade and traffic which, in the course of centuries, transformed the old Saxon Hammaburg into a wealthy hanseatic town and later into the greatest seaport and most important centre of foreign trade in Germany and Central Europe. Historical records show that in A.D. 811 Charlemagne conquered the Saxon fortress; made it the seat of a bishop, and the centre of Christian missionary work in the north. Even in those dark days Hamburg was an outpost of the western world. Eight times it was destroyed by Wends and Vikings, but always rebuilt greater and better by its active and energetic citizens. Another famous German Emperor, Frederick I (Barbarossa) made the year 1189 a milestone in the Hamburg history by granting the Hamburgers their Magna Charta, i.e. the right to trade on the Elbe and the sea without any duties payable to the Reich or local dukes and princes. As this meant the beginning of Hamburg's port activities and seagoing trade on a larger scale, the signing date of this important document, May 7th, 1189, is still annually celebrated as the foundation day of the Port of Hamburg.

The following centuries were still marked by an eventful fate fluctuating between the extremes: Danish Occupation (1201-1227) and the 30 Years' War on the one side and the flourishing period of the Hansa on the other. The gradual growth of trade connections and improvement of transport coupled with Hamburg's unique geographical position on the navigable river Elbe, the focal point of North-West Europe, gave it an increasing importance in the commercial world of the period. The disastrous consequences of Napoleon's blockade of the European continent (1805-1813) and the calamitous fire of 1842 were disheartening set-backs in a rising prosperity. However, the Hamburgers tackled their problems with perseverance and tenacity, and at all periods from A.D. 1258 they carried out port improvements as required by social and political conditions. Corresponding to the state of port technique and shipping of the time all these early projects concentrated only on the deepening of harbour basins and approaches for ships transhipping "midstream," whereas the establishment of quay facilities and thus of modern ports in their present form did not begin until the middle of the nineteenth century.

Modern Development.

Hamburg's first quay district with transhipment sheds and land cranes was put into service in 1866 at the Sandtorhafen in the vicinity of the town at the right-hand side of the Elbe. The quick development of seagoing shipping with the steamer superseding the romantic sailing vessel of former years: the rapid extension of Hamburg's foreign trade and traffic: soon caused an expansion to the left-hand side of the Elbe and, in the following years, one harbour basin after the other was cut into the southern embankment of the river complete with quay walls, sheds, transhipment gear, rail and road facilities.

The relatively small tidal fluctuations—2.30 m. in the average—allowed the establishment of an open tidal port with all the advantages of an uninterrupted in and outgoing traffic at any time. In accordance with the immense importance of inland water traffic to the port, harbour basins were built very wide and equipped with dolphin rows, thus enabling midstream transhipment of bulk goods and uniform bagged cargo. Any disturbance of seagoing traffic by berthed or towed barges was prevented by creating special basins for rivercraft behind those for seagoing ships and connecting them with each other by small water arms.

As soon as the urgent requirements for transhipment facilities were met, the far-seeing Hamburgers started the construction of port warehouses with a view to furthering import trade by giving importers the opportunity to keep substantial stores of goods at hand to meet sudden demands. By pulling down all houses over an area equal to that of a small town and by removing approximately 22,000 people to other quarters an extensive and highly modern warehouse town was erected, which became one of the most important stations in the Central-European import trade.

This was, on principle, the last step towards the creation of a modern port in its present sense. On the constructive field the following years brought a constant extension and improvement of existing facilities in adaptation to the rising traffic and increasing size of the normal freighter. The Elbe tunnel (1911) and the Free Port Elbe-Bridge (1926) were built to cope with the heavy traffic between the city and the centre of port and wharf activities at the opposite side of the Elbe.

By joining the German Custom Union in 1888 Hamburg extended its hinterland and thus its potential traffic volume considerably, but lost, on the other hand, its extra territorial custom status. Instead, it received the free port status, which—unique in Germany—not only allowed a duty-free discharge, examination and storage of goods, but also the manufacture of imported raw materials into semi-finished or finished goods to be re-exported to foreign countries. This benevolent free port status gave rise to the establishment of an extensive and manifold free port industry and—after the completion of the Kiel Canal in 1895—to an essential sea-transit traffic with the Scandinavian countries.

Thus with all natural, constructive and administrative factors combined Hamburg experienced a highly flourishing period and extended the volume of its goods traffic up to 27.7 million tons in 1913. Then came World War I, which, however, only affected the economic basis of the port by reducing the traffic volume and the Hamburg owned merchant fleet. With all port facilities left intact, the consequences of the 1914-18 war were relatively soon overcome; goods traffic amounted to 24.3 million tons in 1923, and gradually increased to the peak figure of more than 29 million tons in 1929.

War Damages and Reconstruction

Incomparably graver was the inheritance of World War II, which meant the heaviest blow of fate in Hamburg's centuries-old history, shaking town and port to their very foundations. When, in 1945, the people of Hamburg started to draw up a balance sheet, they found, that of 563,600 homes, 277,330 had been destroyed entirely and 171,446 partly, only 114,824 homes were left undamaged. A total of 21.5 milliard marks had to be entered on the debit side for damages caused by air raids. About 600 million marks of this sum fell to the port's share, which—having been the sole target for more than 40 major bombing raids—was transformed from a highly efficient transhipment machinery into one of the most destroyed port areas and biggest ship cemeteries of history. A confused heap of debris, destroyed quaysheds and warehouses, disconnected rail and road facilities, 2,900 wrecked ships in harbour basins and approaches, was the condition of the Port of Hamburg in the great stocktaking of remnants in 1945.

Small, deplorably small, was the stock which could be registered in the port area, e.g. 10 per cent. of the pre-war volume of quaysheds, 33 per cent. of the warehouses, 21 per cent. of the cranes and 32 per cent. of the port rail-tracks. Generally speaking, the port's transhipment and storage capacity was reduced to one-fifth. By the loss of these most valuable facilities the heart of Hamburg was paralysed.

The picture presented by the state of shipping was by no means different; in fact, it was gloomier still. Hamburg was the metropolis of the German seamen. For the second time in one and the same generation they had to pay the heaviest tribute imposed upon them by war and defeat. Where were all the proud and world-famed ships of our large companies, the fast steamers of the Hamburg

The Port of Hamburg—continued

Fig. 3. Shed 75, post-war reconstruction. Storage area approximately 20.000 sq. meters. The central tall building houses Administration and Agents offices.

America Line, of the Hamburg-Süd with their flagship *Cap Arcona*, of the celebrated Africa fleet with their 16,000 tonners *Windhuk* and *Pretoria* completed just before the War? Bombed, sunk, carried off and distributed as war reparation. What remained was an insignificant coasting trade, a gross German tonnage of 511 units comprising 200,000 tons carrying capacity was deemed entirely adequate by the Potsdam Conference of August, 1945. The "flagship" of this so-called mercantile marine of 1945 was the *Soederhamn* of 1,469 gross tons, the oldest ship allowed to run was the *Pionier* which had been built 73 years previously! The average age of the remaining steamers was 40 years and that of the coastal motor sailing vessels 30 years, whereas prior to the war an average maximum age of 15 years demonstrated the efficiency of our merchant vessels. In view of all this it seemed hardly possible to speak of Hamburg Shipping at all.

In addition to these visible effects of the war came those less obvious, but by no means less significant in their negative consequences such as the complete collapse of the German economy and traffic, occupation of the whole of Germany and division into originally four, later on two, occupation zones with separate political and economic administration, ban on German foreign trade activities, etc.

Altogether Hamburg's situation was more than gloomy and the prospects for the future hardly better and yet, against these facts and figures on the liability side there stood an asset which was both lasting and indestructible; the deep conviction that this city is bound by the innate obligation which is so eloquently expressed by the saying: " Navigare necesse est, vivere non est necesse! " This undaunted spirit united all shipowners, merchant and their co-workers in their resolve to start the toilsome work of reconstruction.

Already in 1945, Hamburg's Mayor, Rudlof Petersen, in drawing up the balance sheet of the total collapse, declared the re-building of shipping, the port, and of exports to be the city's most important task.

When the first Senate of the Hanse City solemnly took the oath of office in 1946, the President of the City Parliament gave expression to the necessities of the times in the following words:

" Just as the Hanse once took up connections beyond the German border with other nations, so must we to-day attempt to regain our standing in the world by the fruits of our intellect and the work of our hands."

Reconstruction Plans

Intellect and work, these factors really governed the reconstruction of the port, the more so as we did not and could not think of simply restituting the former facilities, but of drawing advantages out of the almost complete demolition by creating new and modern facilities considering both the development of land- and sea-traffic and the technical progress in transhipment techniques. Additional attention had to be paid to the shortage of material and men during the first post-war years and to the restricted financial funds which made it necessary to use existing foundations and partly damaged buildings as far as possible. One of the main problems was the steadily increasing importance of rail and road traffic in the inland transport to and from the port. While the general laying-out of the port corresponded to the former participation of 80 per cent. I.W.T. and 20 per cent. rail traffic, the relation after the war developed to be approximately 50 per cent. rail, 30 per cent. road and 20 per cent. I.W.T. Transferred to the constructional field, this meant extended and improved facilities for the dispatch of waggons and lorries, whereas those for rivercraft could — if necessary — be reduced. Furthermore, it proved expedient to dispatch all rail-traffic at the waterfront of sheds—with the possibility of using quay cranes for direct transhipment into or out of waggons—and to allocate the landsides to road-transport

The answer to these traffic requirements was either to extend the whole quay-district by building new quay walls farther into the harbour basins or to construct the waterfront of newly built sheds not on the old foundations, but transfer it several metres inland (See Plan, Figs. 1/2). In both cases space was created at the waterside not only for two loading and one shunting line of rails, but also for wide ramps (9—11 m.) accessible for lorries for direct transhipment. This far reaching adaptation to the present structure of inland-traffic was supplemented by giving additional groups of tracks at the entrance of each quay-district to rail-traffic for shunting purposes and spacious roads and parking places at the rear of sheds to road transport. All these measures have been provided for and realised in the general reconstruction plan with the exception of extension of quay-district by transfer of quaywalls—as economic reasons made it necessary to use existing quaywalls as far as possible. Only now with undamaged quaywalls being no more available will this method be applied.

In a similar way the increasing draught of the normal freighter and tanker (9—10.5 m.) was taken account of by deepening harbour-basins and approaches to 30—32-feet at low water, a project involving expensive deepening of quaywalls and far-reaching river-regulation works—Tatenberg Sluice.

Special attention was paid to the construction of quay sheds to create the constructional conditions for a smooth and speedy transhipment and storage.

Technical details of interest were the erection of single storeyed sheds of concrete or steel construction, 6 m. in height, with only one row of pillars and spacious windows above the doors, replacing the former sky-lights; the application of a wooden floor cover most suitable to the loose sub-soil in Hamburg, and the concentration of offices and social rooms in a five-storeyed administration building in the centre of the sheds.

The handling equipment of these sheds is up to the latest standard and experiences of transhipment techniques. The highly versatile full portal luffing cranes with a capacity of 3 tons, now widely used, to accelerate transhipment works by enabling two cranes to work at one hold and to combine two cranes for the handling of parcels heavier than 3 tons. They also make it possible to transfer cranes

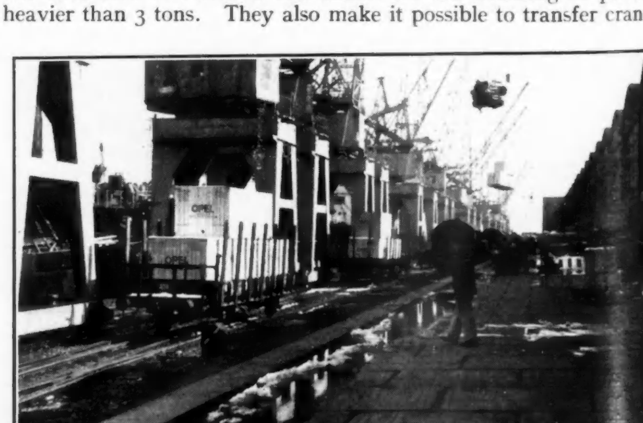


Fig. 4. Unloading cargo at Shed 75. Note dense crane equipment.

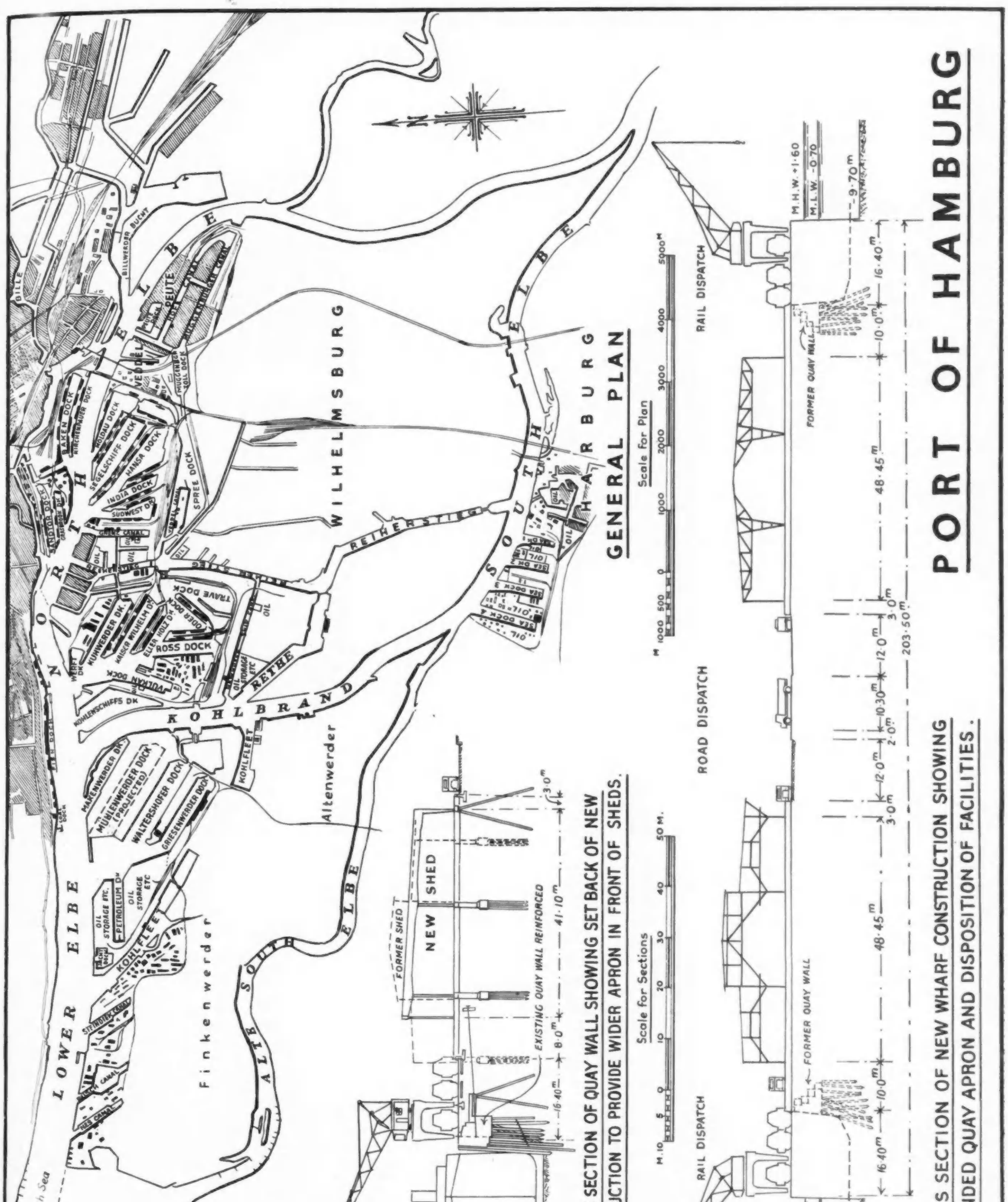


Fig. 1 (left centre), Fig. 2 (below) and General Plan.

The Port of Hamburg—(*continued*)

	1938		1945		1953	
Quaysheds	92		34	= 37.0%	54	= 57.5%
Storage area in quaysheds ... ... including:	725,572	sqm	71,239 sqm	= 9.8%	460,000 sqm	= 63.4%
Fruit Sheds	91,542	,,	—		45,760 ,,	= 50.0%
Warehouses	722,030	,,	236,000 ,,	= 32.7%	346,177 ,,	= 48.0%
Cold Storage	34,739	,,	34,365 ,,	= 98.9%	38,815 ,,	= 111.8%
Fish Halls	22,587	,,	12,120 ,,	= 53.7%	28,697 ,,	= 127.1%
Grain Storage	140,000	tons	175,000 t	= 125.5%	264,650 t	= 189.2%
Tank Storage	1,360,000	cbm	495,831 cbm	= 36.5%	1,095,311 cbm	= 80.6%
Port Railways	450	km	145 km	= 32.2%	441 km	= 98.0%
Cranes	1,108		230	= 20.8%	630	= 56.9%
fl. elevators (grain)	21		8	= 38.1%	17	= 81.0%
st. elevators (grain)	—		—		35	

from one shed to another if necessary. The variety of efficient mechanical handling gear, from ordinary electric trucks over movable shed-cranes to the most useful fork-lifts assists rapid transport and stacking within the sheds, thus making for a smooth flow of cargo from sea-going vessels to the different types of inland transport and vice versa. The fork-lifts, which serve as transport and stacking appliances, have proved very effective in rationalising port work, the more so as the sheds dispose of great numbers of special pallets enabling not only big boxes, but also small crates, cans, bottles, bags, etc., to be handled by fork lifts.

These constructional measures and modern additions to the port's working facilities despite the shortage of space have contributed considerably to the quick restoration of the Port of Hamburg as one of the most efficient and speediest transhipment places in international sea-traffic.

The Port To-day

The Port of Hamburg, situated at the junction of the Northern and Southern Elbe approximately 76 miles from the open sea, 56 miles above the Elbe estuary at Cuxhaven and 40.5 miles above the Brunsbuettel entrance to the Kiel Canal has become again the greatest German seaport in respect of extension, capacity and traffic volume. In its present form it covers an area of 9,450 hectares = 23,825 acres, comprising 14,468 acres land surface and 9,357 acres water surface and embracing 38 harbour basins for seagoing ships and 32 basins for inland water craft.

As a "universal port" it handles all commodities of the world market correspondingly disposing of suitable transhipment and storage facilities for all types of cargo.

The table at the top of the page gives some figures and data which prove the all-round character of the port, simultaneously illustrating the heavy war destructions and the impressive progress made during the past eight years since 1945.

In consequence of these favourable reconstruction results it has been possible again to give each of the 191 regular liner services special sheds for the expedition of their ships with a harbour office for the respective ship's agents, which means an essential facilitation for both the dispatch of ships as well as the disposition of export cargo. Larger lots of export goods may thus be sent directly to the normal expediting shed of the liner service in question whereas collective consignments will either be directed to shed 2/3 (road transport) or shed 54/55 (rail transport) where they will be sorted out, distributed according to their destinations and loading ships, and transported to the ship's berth by means of harbour craft, lighters, barges, etc.

Last, but not least in a modern port-service may be mentioned the advantages given at 65 quay and 8 dolphin berths to connect ships directly with the German and international telephone net by installing telephones on board. So much about the facilities for general cargo and normal lines, which though quite valuable, do not yet make a universal port.

Special Installations

1. **Fruit Sheds.**

   The former centre for the handling of fruit, situated in Baakenhafen, was completely destroyed and has been removed to the Segelschiffhafen where already 5 heated fruit sheds, Nos. 34 to 37 inclusive and 48 are available, which, together with the sheds 57A and 82B, dispose of an area of 45,760 sq. m. A special banana handling apparatus was transferred from shed 35 and installed in the newest construction, shed 37, on completion of the latter in November, 1950. The average shift performance per ship is 600 to 700 tons. When the fruit season closes these sheds serve as a very valuable aid to the facilities, ignored by force of circumstances in the reconstruction programme, necessary for the handling of the coastal and short sea trade.

2. **Cold Storage.**

   The 5 refrigerated stores remained almost undamaged and with a storage space of 38,815 sq. m., offer facilities for rapid and direct transhipment of seagoing vessels. The modern technical equipment within the cold storage plants, which are fully employed at present for chilled and frozen cargoes, permits the easy individual handling of the goods stored.

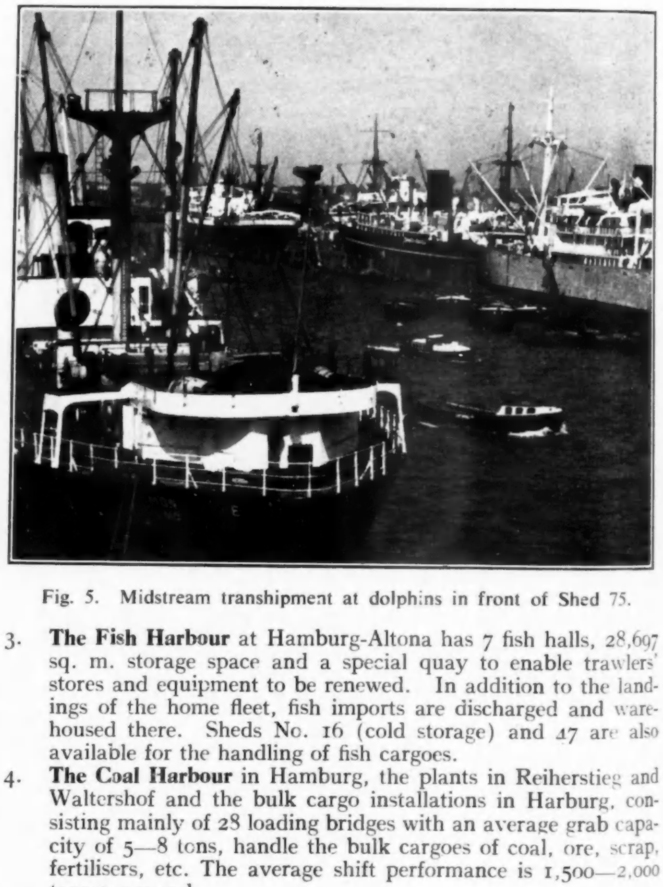


Fig. 5. Midstream transhipment at dolphins in front of Shed 75.

3. **The Fish Harbour** at Hamburg-Altona has 7 fish halls, 28,697 sq. m. storage space and a special quay to enable trawlers' stores and equipment to be renewed. In addition to the landings of the home fleet, fish imports are discharged and warehoused there. Sheds No. 16 (cold storage) and 17 are also available for the handling of fish cargoes.
4. **The Coal Harbour** in Hamburg, the plants in Reiherstieg and Waltershof and the bulk cargo installations in Harburg, consisting mainly of 28 loading bridges with an average grab capacity of 5—8 tons, handle the bulk cargoes of coal, ore, scrap, fertilisers, etc. The average shift performance is 1,500—2,000 tons per vessel.
5. **The Petrol Harbour** at the entrance to the Port of Hamburg and the oil installations and refineries in the Köhlbrand and in the Deep Sea Basins III and IV at Harburg are available to deal with the increasing number of tankers (250,000—300,000 tons per month). The installations are provided with sufficient deep draught berths, high capacity pipe and pumping plants and storage tanks for all types of mineral and fuel oils. The

The Port of Hamburg—(continued)

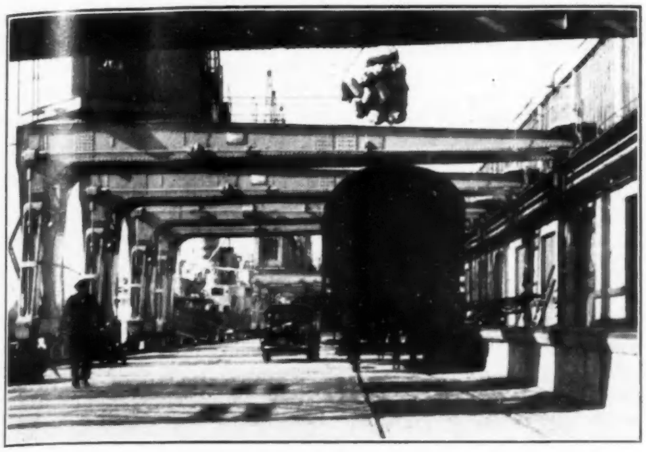


Fig. 6. Shed 34, post-war reconstruction. Fruit shed thermally controlled.

average duration for the despatch of a 15,000 ton tanker is 15—20 hours. Possessing 35 per cent. of the total German oil refineries and 1,095,311 cu. m. tank storage, Hamburg is again the most important German source for the import and refining of crude and fuel oils.

6. **The Potash Plant** in the Rethe offer most efficient handling and storage space for potash, rock salt, etc. The total capacity is 80,000 tons and the installations are constructed to load bulk and bagged cargoes direct from railway trucks or warehouse to vessels. Average shift performance per vessel 1,200 to 1,600 tons.
7. **The Grain Silos** situated on the North Shore of the River Elbe at Altona Neumühlen and in the Rethe embrace 35 shore based elevators capable of discharging in many instances even larger type vessels, direct to silo, rivercraft, road transport and railway trucks or receiving from harbour craft, cargoes discharged from vessels at the midstream dolphin berths. 9,000 grain vessels are normally discharged by means of 5 floating elevators at the dolphin berths, the average shift performance being 4,000 to 5,000 tons. This type of vessel can also berth and discharge direct at some of the Rethe silos.
8. **The Warehouse Town** with a storage space of 346,177 sq. m. serves the warehousing of goods for long term periods. These goods are retained in the port as a permanent reserve and called forward as necessary by the importers. The appropriate type of warehouse together with experienced storekeepers (Quartiersleute) well versed in the essential arts covering the storage of all types of wares, guarantee special handling of the goods concerned.

While reconstruction is still continued at a programmed annual rate of 50,000 sq. m. storage area in quaysheds, 25,000 sq. m. in warehouse and 1,250 m. of quaywalls the above is about the picture of the present facilities which guarantee careful and individual treatment of goods of any type and forms the constructional basis for the world-known speediness of transhipment performance in Hamburg.

The other features enabling this port constantly to increase its transhipment speed lie in the quality and experience of the port working firms and their labour force as well as in the adaptable general working organisation of the port. Following the dispatch of ships calling on Hamburg the *Ships Reporting Service* with its signal - stations in Cuxhaven, Holtenau, Brunsbüttelkoog, Stadersand and Hamburg renders the first contribution to a quick turn-round by informing all port authorities and private firms concerned of the approaching ships, thus enabling them to take the necessary preparatory measures. In this connection it proves highly advantageous, that the Port of Hamburg does not know any restriction of working regarding time or number of dockers required. We work, if desired, "*round the clock*" throughout the 24 hours of a day—on weekdays in 3 shifts of 8 hours each and on Sundays in 4 shifts of 6 hours—and our *versatile system of port labour* puts us in the position to satisfy even peak demands for dockers. In addition to the approximate 8,000 permanent workers of the various companies the port disposes of a dockers' pool of about 4,000 men in the Gesamthafenbetrieb (General Port Company) and of a reserve of workers held on call to any required extent, sometimes up to 3,000 men a day by the Labour Office. As all registered port workers receive guaranteed wages for 6 or 5 days respectively a week even in case of unemployment, Hamburg can pride itself on having a " good social climate " in the port and of having experienced no general strike since 1945. These are the reasons for the fact that all incoming ships, should they arrive during day or night-time, or even on Sundays, may start transhipment works at once with such numbers of dockers as they desire.

The readiness of sheds to accept new cargo is helped by the usual speedy removal of in-bound goods effected by the dense network of the Federal Railways, with its highly developed transit trade aided by the inland waterway shipping facilities on the River Elbe, its subsidiaries and communicating canals.

The outcome of this well-planned co-operation is uniform and high output in the handling of all freight categories which is one of the main attractions of the Port of Hamburg.

While in individual categories some ports might be faster, such as specialised bulk cargo ports, few ports are likely to be in the position to discharge 9,000 ton grain vessels and 16,000 ton tankers in less than 16 hours, while at the same time off-loading 1,900 tons of general cargo in 20 hours, 1,360 tons oranges in 16 hours and 12,913 tons of coal in 38 hours or loading 8,800 tons potash in 38 hours. It is not on isolated individual performances but on the high average in all vessels and all categories of freight that the international reputation of Hamburg is founded.

While a fast turn-round is always likely to range second to none in the wishing-list of shipowners towards transhipment places, importers and exporters here and abroad might be more attracted by the advantages offered by the Hamburg Freeport.

Free Port Facilities

The Freeport, created in 1888, covers 3,337 acres and embraces most of the sheds and warehouses, some plants for bulk cargo and numerous industrial undertakings such as refineries for mineral oil and oil-fruit, grain mills and factories of the chemical and pharmaceutical industry.

Having the status of an extra-territorial area it offers the possibility of a duty-free discharge, examination, and even long-term storage of import cargo (duty is not payable before the goods cross the freeport frontier) thus not only facilitating import formalities, but also enabling foreign exporters to keep stockpiles on consignment within the freeport, which considerably increases the prospects of sale.

Moreover, the freeport status is the legal basis for the sea transit traffic, duty free transhipment between oversea liners and smaller vessels of the Baltic Sea routes and vice versa, as well as for the activities of the freeport industries which import their raw materials

Fig. 7. Interior view of Shed 58 nearing completion.

The Port of Hamburg—continued

free from customs duty and re-export their semi or finished products without customs restrictions.

It is the efficiency and versatility of the port installations, the adaptability of its working organisation, and the advantages of its freeport territory combined with the supporting assistance of the Hamburg foreign trade and shipping companies that the ships' and goods traffic, as well as the frequency of liner sailings—at present about 500 monthly departures to 779 world ports—have shown a continuous upwards tendency since 1945.

Year.	Traffic ships (in millions n.r.t.).	Traffic goods (in millions t.d.w.).	Average monthly liner sailings.
1946	3.0	4.2	no figures
1947	3.5	6.0	available.
1948	5.8	7.9	141
1949	8.9	9.6	202
1950	11.2	11.0	319
1951	12.4	14.2	401
1952	14.3	15.2	446

Fig. 8. Railway wagons for export being loaded by floating crane.

These figures certainly make a good impression and we are, in fact, rather happy to have reached them, but there are still some disturbing factors spoiling our self-satisfaction. At the same time we are fostering our will to continue our efforts for a further ascending development.

A comparison with the last normal pre-war year 1936, e.g. reveals that Hamburg with its 15.2 million tons transhipped in 1952 reached only 69 per cent. of its former traffic volume, whereas all neighbouring western ports from Bremen to Antwerp ranged between 119 and 145 per cent. of their respective 1936 traffic. Consequently Hamburg's share of the foreign trade of the Federal Republic only amounted to 28.8 per cent. in imports and 21.9 per cent. in exports as compared to 39.7 per cent. or 28.0 per cent. respectively before the war. The same refers to the size of the German merchant fleet, at present totalling approximately 1.6 million net register tons compared to 4.5 million N.R.T. in 1938, and its participation in the total cargo traffic of this port which in 1952 was only 33 per cent. altogether, and only 15 per cent. in the important oversea-relations. These figures prove that the port has not yet been able to overcome the inheritance of war, especially the loss of about half of its natural hinterland by the political division of Germany and Europe.

Nor have the German shipowners been in the position to build a sufficient number of ships during the two years, since April, 1951, of unrestricted shipbuilding. So with both, port and shipping, we have not yet reached such participation rate in our German foreign trade as is internationally regarded adequate for national ports and fleets, hence there is hardly any justification for the complaints so often voiced in international shipping circles and papers of indiscriminate and dangerous German competition.

On the contrary, we Hamburgers are not in the position to counter-balance the handicap inflicted upon us by world politics by our own efforts only. We hope for the support not only of our Federal Government and German economy, but also of the entire western world, as whose most exposed outpost Hamburg has for years already played an important mediatory role in international trade and traffic.

New Port for British Columbia

To Serve Kitimat Aluminium Project

By JOHN GRINDOD, B.A. (Com.).

Taking shape in British Columbia, some 400 miles north of Vancouver, is Canada's newest and most modern deep-sea port on the Pacific Coast. Incorporating an extensive modern wharf, large alumina, coke and other storage facilities, and serviced by high-speed handling equipment and the latest cargo unloading methods, the new port is intended to be opened for traffic in the autumn. It will chiefly serve the new Kitimat, B.C. smelter of the Aluminium Company of Canada Ltd. (Alcan), a $550 million project expected to produce 500,000 tons of aluminium annually.

The Canadian National Railways are also bringing down a spur railway line to link Kitimat with Terrace, B.C., on the Prince Rupert-transcontinental line. In due course it is expected that new industries will be attracted by the cheap power and shipping facilities available, and a new townsite will be located on the opposite side of the Kitimat valley.

Side by side with the development at Kitimat, B.C., is the construction of facilities in Jamaica, where alumina for use in the B.C. smelters will be extracted from bauxite, mined in the neighbourhood by Jamaica Bauxite Limited, a subsidiary of Aluminium Limited. The new plant established near Manderville, Jamaica, will be producing at least 450 metric tons of bauxite per day by late 1953 and a deep-sea port with a 600-ft. steel and concrete pier is being created at Old Harbour Bay to despatch shipments. The alumina will be moved to the port in railway wagons, unloaded into storage tanks and discharged by a 1,400-ft. long conveyor to the pier. Representating an innovation in shipping methods, the alumina will be transported to B.C. in bulk and unloaded directly into storage facilities at Kitimat, located 800 yards from the wharf. By shipping alumina instead of bauxite a transportation saving of more than 50 per cent. will be achieved.

Located some 80 miles up a deep channel from open water, Kitimat has a sheltered, ice-free harbour which has been further deepened by dredging. The dredged gravel has been used to raise and consolidate the soft, rather spongy land on which storage sheds, etc., will be built. The connection with the dredge was made by a 24-in. pipeline through which the fill was pumped at a rate of 12,000 cu. yards every 24 hours.

The Kitimat wharf is 750-ft. in length, and the dock has been made by three concrete caissons, each 250-ft. in length, 45-ft. wide and 60-ft. high, which were built in a graving dock, towed to the dock site and sunk into place. Designed with 26 chambers, the lower ones of which were closed up with timber bulkheads, each caisson was towed into position complete with a pump for each chamber, a radio telephone and a crew of 40. Floating on their sides till they reached the site, each was turned and sunk on its base in 40-ft. of water.

Now capable of handling ships drawing more than 32-ft. of water, the dock will be equipped with standard Kangaroo cranes and special alumina unloading and handling equipment. This will include a pneumatic unloading tower, operating on a suction principle by electrically-powered vacuum pumps. Having a capacity of up to 180 tons per hour the tower has been specially designed by the British firm of Simon Handling Engineers, Ltd., of Cheadle, near Stockport. A 42-in. conveyor belt will run along the whole length of the wharf. Initially, the wharf will be capable of handling three ships, and later six.

Already operating a shipping service between Montreal and Vancouver, and connecting up the existing Alcan aluminium plant at Arvida in Quebec with the new one in the west, Saguenay Terminals Ltd., the Alcan shipping subsidiary, is to put seven ships on the B.C. run, extending it to Kitimat this month with a fortnightly service. This service will take in the ports of Halifax, Saint John, Kingston, Jamaica, the Canal Zone and U.S. Pacific ports.

Kitimat will also be included as a regular port of call on Saguenay's Pacific Coast, Canal Zone, Venezuela, Netherlands W.I., Trinidad and Demerara.

The initial cargoes will consist of machinery, equipment and general cargo for Kitimat and supplies of raw material. The estimated turnover at the new port is a million-and-a-quarter tons of cargo a year.

Oscillations of the Sea and the Phenomenon of Range

Part 3. Ocean Waves and Sea Vibrations (II)

By B. W. WILSON, D.Sc., C.E. (Illinois), A.M.I.C.E., Assoc.M.ASCE., A.M.(S.A.)I.C.E.

(continued from page 77)

Ground-Swells.

Scott Russell referred to the Cape rollers as ground-swells and waves of translation and the implied meaning of this reference is clearly therefore to a wave that produces an oscillatory mass-movement of the water from surface to sea-bottom. Lacey[22] defines a ground-swell as the product of wind-waves generated in a distant part of the ocean; their effects, he says, penetrate to greater depths than ordinary waves, and on approaching shallow water they exert more powerful percussion-effect on sea walls, while their backwash is more destructive to beaches. Elsewhere Lacey remarks[23] that they are usually observed to set in after the lapse of strong winds. A somewhat similar observation is made by Mitchell[24]:

"... the long, smooth undulations of a heavy ground-swell, with their enormous destructive energy, occurring as they did after a storm had abated and when the weather was perhaps calm and fine, were the result of oscillations which had been gradually set up in a large mass of the sea by the wind."

While mariners and harbour engineers have always been conscious of ground-swells, the conception of their nature has remained rather nebulous. Scott Russell, for instance, considered the Cape rollers of 15 to 20 second periodicity to be ground-swells, as well he might, since Fig. 3 shows that by the time they have entered 80-ft of water the bottom surge is 80 per cent. of the surface movement. But how are we to align this fact with the observations of Mitchell and Lacey that ground-swells develop after the lapse of winds and the abatement of a storm? Since ground-swells are necessarily long waves, should they not rather precede the wind than follow in its wake? If they are, in point of fact, wind-generated, as Lacey suggests, they must, in virtue of their greater velocities, outrun both the wind and the ordinary swell and thus anticipate the latter's arrival. The recent work of Barber and Ursell shows that the 15 to 25 second swells definitely precede the shorter ones, their order of arrival being strictly in accordance with the theoretical dictates of their relative speeds. This anomaly must then await elucidation from other facts still to be presented.

At this stage we may venture to offer an interpretation of a ground-swell as being any particular wave which within a depth of say 80-ft. of water (in the precincts of a coast, bay or harbour), exhibits an oscillatory mass-movement of water of which the surge on the sea bottom is at least 80 per cent. of that at the surface. According to this definition all waves falling within the shaded zone to the left of the 0.80 diagonal line of Fig. 3 will be ground-swells.

As an earlier discussion has revealed, 25 seconds appears to be the approximate upper limit of visible swells. The gradual diminution in magnitude of the swells as they approach this limit is well portrayed in Barber and Ursell's wave spectra. Unfortunately, the frequency band of sensitivity of their recording instrument does not seem to have been wide enough to register swell-periodicities above 30 seconds and there is no evidence from this source of the existence of longer swells than about 25 seconds period, such as might be of a very low frequency and very small amplitude, preceding the visible waves.

It seems that the existence of the invisible long waves of the sea, similar to those detected by Forel and Chrystal in lakes, must be inferred from the embroidery on the marigrams of tide-gauges or wave-recorders located at points where, through shelving ground and reflection, they can accumulate to measurable proportions. Recently (1948), an instrument has been brought into use at the end of the Scripps Oceanographic Institution's Pier at La Jolla, California[25], which, through special design, is able to detect wave periodicities up to 25 hours; but gives best response to wave-periods between $1\frac{1}{2}$ minutes and $2\frac{1}{2}$ hours. Records so far obtained apparently prove the existence of complex wave-systems within these frequency bands. Munk[26] has sought to interpret some, at least, of these waves as being the result of accumulations of water brought shorewards by groups of high visible waves. The resulting surges he has called "surf-beats," and their existence from this cause would seem to have been confirmed by Tucker[27] and Barber[28] in Britain. Tucker obtained simultaneous records of long and short waves arriving off the coast of Cornwall at Perranporth, and found a strong correlation between the long waves and the envelope of the short waves suggesting that the formed lagged behind the latter by about 4 to 5 minutes.

The Destructive Power of Ground-Swells.

The accounts are legion of the havoc and destruction wrought by long waves in harbours and along the coasts. The most dangerous ground-swells, visible and invisible, originate from the centres of the equatorial cyclonic storms, as has been proved repeatedly by the subsequent devastating inundations marking the arrival of the cyclones themselves. If the track of an intense cyclone crosses a coast, as it sometimes does, the chances are that great waves of the character of seismic sea-waves will flood the shore. But even if the cyclone veers off from the land it will often send great waves rolling towards the coast, capable of wreaking considerable damage.

The Coromandel (east) coast of India is much subject in this way to the invasion of cyclones originating in the Gulf of Bengal[29]. During the south-west monsoons of the May period the cyclone-tracks swing northward clear of the land, but in the north-east monsoon period of October, the cyclone-tracks are westward towards the coast and only swing northwards at a late stage. It has always been a mystery why the shore-line along the Coromandel coast accretes with the south-west monsoons and erodes with the north-east, but it is probable that the explanation lies in the essentially different character of the waves in the two seasons. Mild and distant cyclones would give rise to weak ground-swells and short-period oscillatory waves whose forward momentum could be expected to occasion a sand-drift shorewards, while intense and proximate cyclones would generate strong ground-swells, whose powerful backwash could easily provide the denuding agency.

The destructive nature of big waves experienced along the Californian coast of North America has been vividly described by McEwen[30] and by Leypold[31]. The latter has presented convincing arguments for associating severe beach-erosion there with coastal seiches of the shorter-period types, developing from the long waves spread by Pacific typhoons and cyclones, 5,000 miles away.

Wherever cyclonic storms and travelling depressions are cradled into being over the wide expanses of oceans the story is the same. Off the east coast of Madagascar the cyclone-tracks run on a W.S.W. course but swing southward usually before they reach the coast: hurricanes play over the east and west coasts of Australia with the same directional sweep, and south-eastwards across Cape Horn in South America. In the northern hemisphere the trend of hurricanes and typhoons is north-westwards against the east coasts of America, Asia and India. In higher latitudes the spawning grounds of the more common travelling depressions are located near the barometric high-pressure belts over the oceans, and the directions of travel are from west to east. As Lacey has shown[32], these cyclonic depressions, although much less violent than the cyclones, hurricanes and typhoons of the equatorial regions, are capable of raising phenomenal waves and tides, and are a prolific source of ground-swells.

Oscillations of the Sea and the Phenomenon of Range—continued

The Connection between Ocean-Waves and Range-Action.

The commotion which a near or distant storm is capable of causing within the precincts of a harbour has been variously referred to as scend, undulation, run, surge, swell, ground-swell, surf, or range-action, but "Range" appears to be the accepted technical terminology adopted by the engineering profession[33] for the peculiar phenonmenon which causes ships to surge at their moorings, often for no apparent reason. What appears to be the earliest indirect reference to the existence of Range as a problem in harbours comes from Thomas Stevenson in 1864. In discussing the natural causes which tend to prevent the silting up of harbour entrances, he remarks[34]:

"The ordinary waves produced by a gale and the 'run,' wherever there is a ground-swell, are, I think, the agents which possess all the powers that are required."

Although Stevenson apparently made no other special mention of "run," there was obviously no doubt in his mind of its dependence on ground-swells, as distinct from ordinary waves.

The first really comprehensive references to Range action are to be found in a series of papers on wave-action in harbours prepared as a symposium for discussion before the Institution of Civil Engineers, London, in 1919[35]. In the second of these, Hindmarsh defines "Range" as sea-action; in the third paper, Sandeman gives Range a more specific meaning. He proposes that the term should apply only to waves from the sea that have penetrated into a harbour, as distinct from short wind-waves that have been whipped up inside the basins. Sandeman records that Range-waves from 6 to 24 inches in height with periods of from 40 seconds to 2½ minutes were experienced in the harbour of Blyth, facing the North Sea: the momentum imparted to heavy ships with slack moorings had frequently proved sufficient to break steel hawsers up to 5-in. in circumference. The first and the fourth papers describe the North Sea harbours of Whitby and Sunderland respectively where the problems of Range had to a large extent been overcome by the construction of enveloping, outer breakwaters: their authors, Mitchell and Simpson, do not, however, attempt to define Range other than as an ingress of swell into the dock areas.

In the resulting discussion Sir Francis Sprigg gave as his interpretation of Range:

"... the surging and shifting, to and fro and round about, of the deep solid body of water in a harbour, due to the repeated access of swell from the outside through the entrance, a movement acting so deeply as to carry with it heavy vessels for a distance perhaps of three or four feet bow-wards or stern-wards two or more times in a minute, with a force which might easily snap a 6-in. wire line or a 15-in. coir spring."

Sprigg considered that the translatory nature of the swell in the shallower depths of a harbour would tend to raise the level of the enclosed water, which would be balanced by an outrunning current, perhaps in the lower half of the depth at the entrance. The result of this simultaneous inflow and outpour would be a surging movement of the mass of the enclosed water. He cited as an example of this the movement that occurred in Madras harbour:

"Even in the enclosed 9-acre 'boat basin,' at Madras with its 80-ft. entrance and 12-ft. depth, ¾ mile in from the 400-ft. main harbour entrance, the effect of Range had been most troublesome for a few hours at a time, all the small craft from his own dredgers downwards, that had taken shelter in the basin, being slowly moved about a foot or two forwards and backwards with a force that could with difficulty be withstood by the necessarily short lines and cables with which they had been moored; and all this with no waves to speak of."

Sprigg remarked further that Range of this character occurred at Madras only during a couple of months of the year, and then perhaps only on one or two days of those months.

Mitchell, in his reply to the discussion, introduced the idea of ground-swells being responsible for Range-action, as we have already recorded. His further account of the phenomenon goes far towards explaining it. The whole body of water in a harbour, he contended, was gradually set in oscillation by the impression on the entrance, in regular pulses, of enormous quantities of energy derived from the incoming waves. In many harbours there would probably be more than one period of oscillation, the periods depending on the volumes of the water-masses, their shape in plan and section. Amplitudes would depend on the energy-input and friction-losses and the degree to which the period of swing agreed with that of the entering waves. Although Mitchell refers to the work done on analogous oscillations in well-known lakes, and was thus the only harbour engineer among the many prominent men taking part in the discussions to adduce the phenomenon of seiches, he does not actually introduce this term.

The positive connection between coastal seiches and Range-action was established experimentally in 1935 by Barillon[36] in respect of the harbour of Tamatave on the east coast of Madagascar. Here ships were found to break their moorings by responding to strong surges with a periodicity of the order of a minute, when the visible swell out in the roadstead had a period of only about 10 seconds. On constructing a model of the bay and harbour Barillon found that by impressing upon it paddle-generated swells of certain periods, resonant oscillations could be induced alongside the quays. These resonant frequencies seemed to be related to each other and were not altogether dissimilar from the calculated critical modes of oscillation for the bay of Tamatave, regarded as a semi-conical canal open to the sea at its wide extremity. So far as is known this was the first practical demonstration by model of this type of problem. Barillon had been led to his line of investigation by Defant's account of sea-vibrations and of the work of Chrystal and Forel. Barillon's studies were incomplete, however, and required substantiation from actual prototype measurements.

If Barillon's was the first model-study to be made of the Range-phenomenon, it is certain that at that time the problem was already well understood by Leypold[37] and others in America. Most of the large harbours along the Californian coast exhibited the marigram-embroidery, characteristic of Range, and a certain amount of trouble had been experienced in the mooring of ships. The first experimental study of Range to be undertaken in the United States (Los Angeles Harbour) appears to have been initiated at about the same time (1943) that similar investigations were started at Cape Town, South Africa, in respect of Table Bay Harbour, with which the writer was directly connected. The American studies were undertaken at the California Institute of Technology, Pasadena, under the direction of Professor Knapp, and also at the Vicksburg Engineering Experiment Station. Since that time a great many more model-studies of wave and surge problems have been instituted at Vicksburg in connection with Anaheim Bay and Monteray Harbour, California, and the Midway Islands, Hawaii, to mention but a few[38]. The special difficulties encountered at Los Angeles as a result of Range are described by Leypold in a discussion on a paper by Edwards and Soucek, dealing with surges in the Panama Canal[39]:

"In Los Angeles Harbour, numerous continuous seiches occur. Those with relatively long periods have little or no effect on ship manœuvring, whereas the short period seiches are a serious problem, especially in the naval base area where caisson gates for graving docks must be fitted into rather small keyways during the closing operation. The surges accompanying the seiches, with their rapid direction reversal, make the locking operation difficult."

Earlier Leypold accounted for these phenomena by saying that

"Seiches in nature are produced chiefly by differences in barometric pressure on water surfaces in the same oscillating area, or by tidal effects."

It now seems apparent that most harbours of the world are subject, in degrees more or less, to the disturbances arising from the penetrative power of long ground-swells[40]. There is evidence that the Range phenomenon is common to many of the ports on the east coast of New Zealand and the west coast of Australia. On the west coast of South America, the Chilean ports of Santo Antonio, Iquique, Antofagasta and Valparaiso are afflicted with rather serious Range troubles which necessitate ships leaving the quays on occasion[41]. Significantly, these difficulties are attributed to cyclonic storms over the Pacific Ocean.

Table Bay Harbour at Cape Town, owing to its openness to the eastbound storms of the South Atlantic, is also much affected by Range-action[42]. During the critical years 1940-42 of World War II, when large convoys of big ships were using Cape Town as a port of call on the route to the east, considerable trouble was experi-

Oscillations of the Sea and the Phenomenon of Range—continued

enced from the surging of vessels at their moorings. Although the problem had long existed, it required a crisis of this nature to motivate studies directed towards its solution. Mr. George Stewart, at the University of Cape Town, anticipated the official investigation of the South African Railways and Harbours Administration by constructing, in 1941-42, a small model of Table Bay Harbour, in which he succeeded in reproducing the main features of the phenomenon. His findings[43], however, do not reveal a very full study or understanding of the problem, and his conclusion that *swell* and not *sea* is the cause of Range, requires qualification.

The larger model of Table Bay Harbour constructed by the Railways and Harbours Administration in 1943 has permitted of the mechanism of Range-action being studied in considerable detail and the essential nature of the phenomenon can be said to have been correctly interpreted by Mitchell, as already described. There seems no longer any doubt but that Range or Run in harbours is the result of seiches, or standing waves, peculiar to the special shape and depth of the harbour basins, of any external bights or bays which may contain them, or, even, of submarine canyons flanking the neighbouring coastline itself. The seiches are engendered by the reflections of incoming trains of waves or, alternatively, by the superposition locally of barometric fluctuations of quasi-periodic nature, and possibly by a combination of both, since intense winds and storms that blow home to a port are inevitably intrusions of atmospheric commotion.

Since a seiche constitutes a mass-movement of the whole body of water in an oscillating area, in which every particle of water moves synchronously with the same period and phase as every other particle, it is understandable how ships are adversely affected at quays where the boundary conditions are unfavourable and the movement is strong. The flux and reflux through basin-entrances, which is so characteristic of Range and gives rise to the term Run, is the necessary mode of impulsion whereby the external seiche or ground-swell communicates the oscillations to the inner basins.

In the previous sections we have endeavoured to show that most of the harbours of the world are affected to some degree or other by the Range-phenomenon. Wherever the troubles are particularly severe it is noteworthy that the harbours front on wide expanses of ocean within the equatorial or polar-front belts, where travelling depressions or cyclones converge towards the harbours concerned.

There is now definite evidence that barometric disturbances over the oceans, in the form of cyclonic depressions in the high-pressure or polar-front regions, or their more violent counterparts such as cyclones, hurricanes and typhoons in the equatorial regions, give rise, not only to visible wind-waves and swells, but also to invisible ground-swells of great lengths, capable of travelling vast distances without change of form other than that which arises from shelving ground. Similar wave-trains may be caused by seismic upheavals, earthquakes, or tremors of terrestrial or submarine origin, but their incidence from this source is very much more sporadic.

These complex wave-trains contain waves of all periodicities and wave-lengths of which the longer ones precede the shorter. As with the ripples made by a stone falling into water, the long waves are of small height while the shorter waves carry more elevation. From this assortment, the submarine canyon, the bay, the bight, or the harbour-basin selects those waves whose periodicities most nearly agree with its own natural frequencies of oscillation, and under their stimulus gives rise to the various multinodal seiches to which it is attuned.

In this section, we may endeavour to define more closely the origins of ocean waves and ground-swells and their dependence on meteorological conditions.

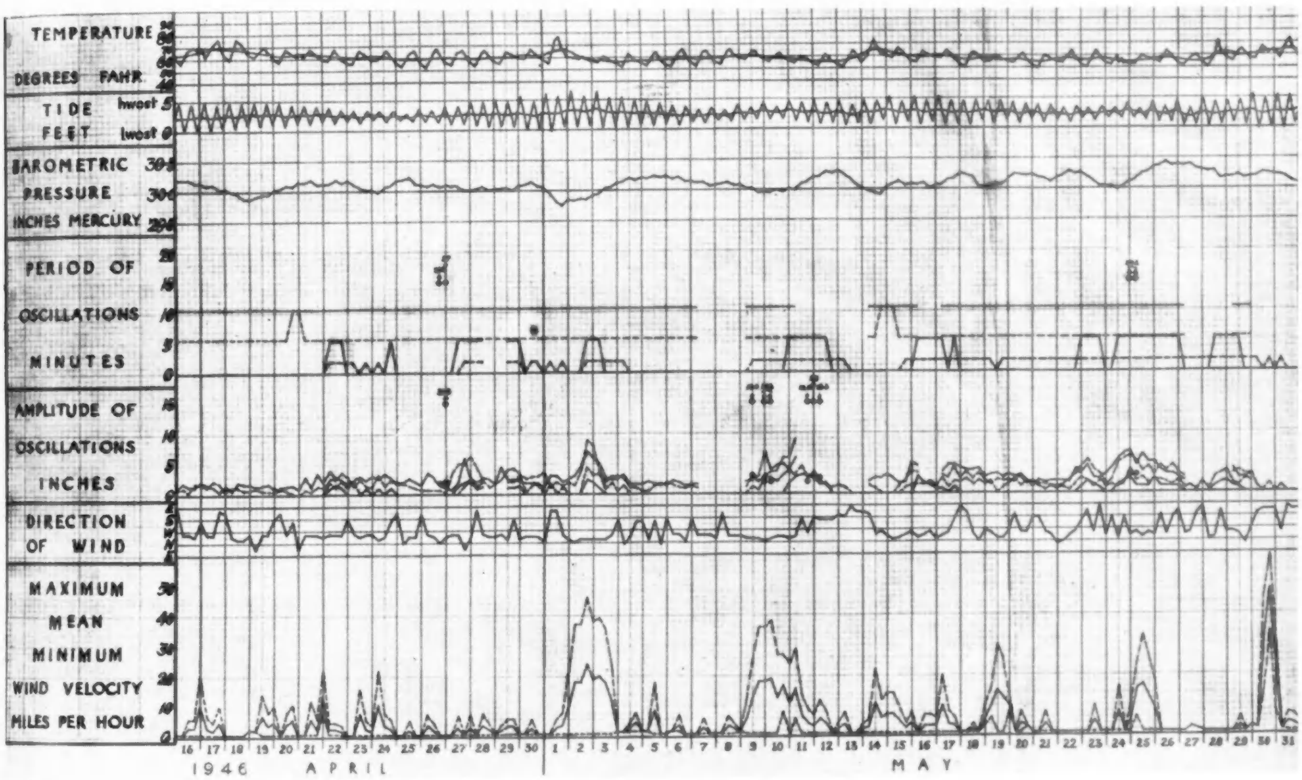


Fig. 4.

The Association between Range and Frontal Depressions.

The writer's studies of the Range problem at Cape Town amassed further evidence, in support of that derived from other sources previously mentioned, that an obvious *general* association exists between Range-action and barometric depressions. Fig. 4 is fairly typical of the relationships found to exist between local weather conditions (during the winter months of 1946) and the amplitudes of oscillations measured at two tide-gauge positions in the harbour. Such relationships have now been plotted for an entire decade from 1941 to 1951, but they fail to reveal any single

Oscillations of the Sea and the Phenomenon of Range—continued

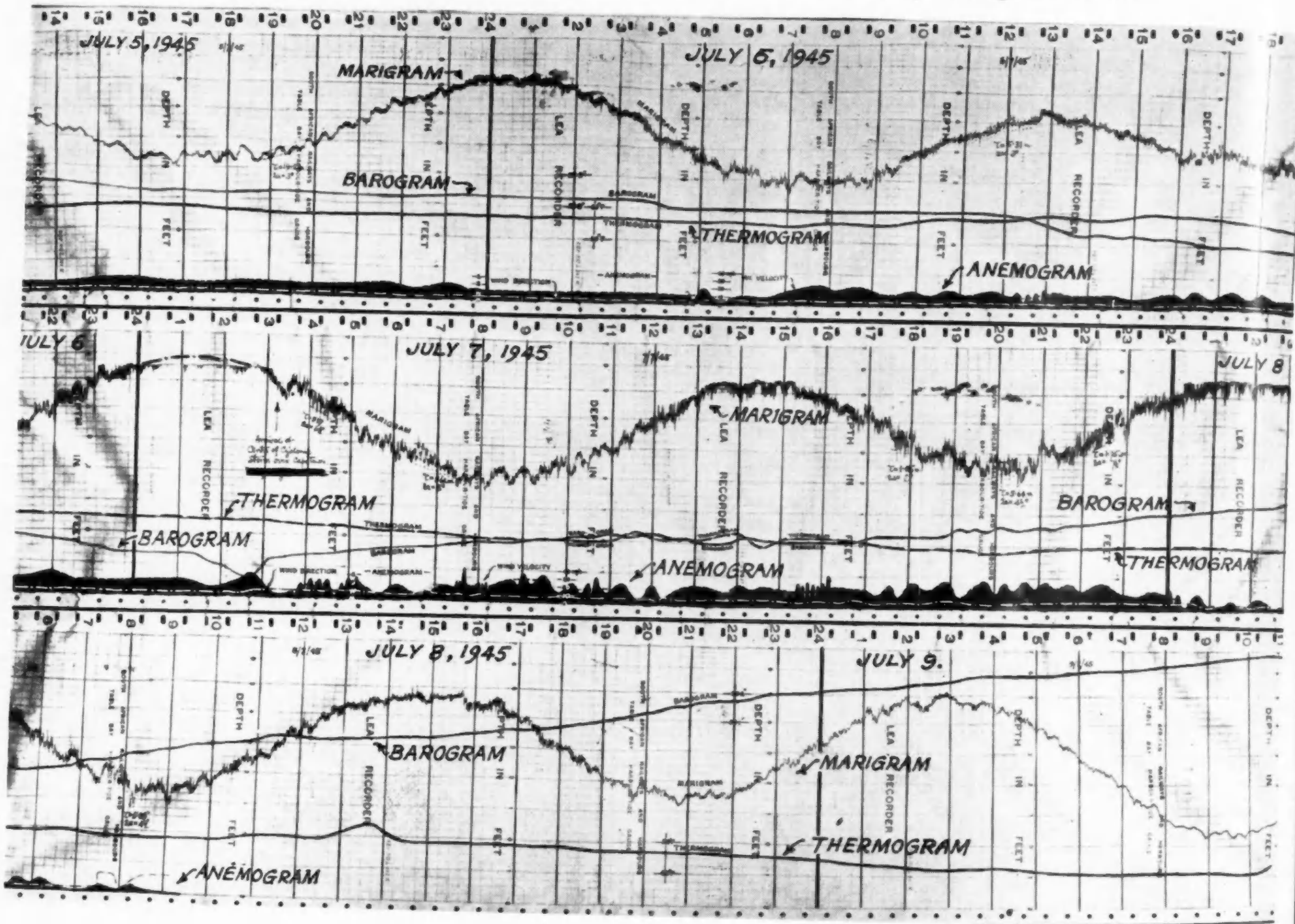
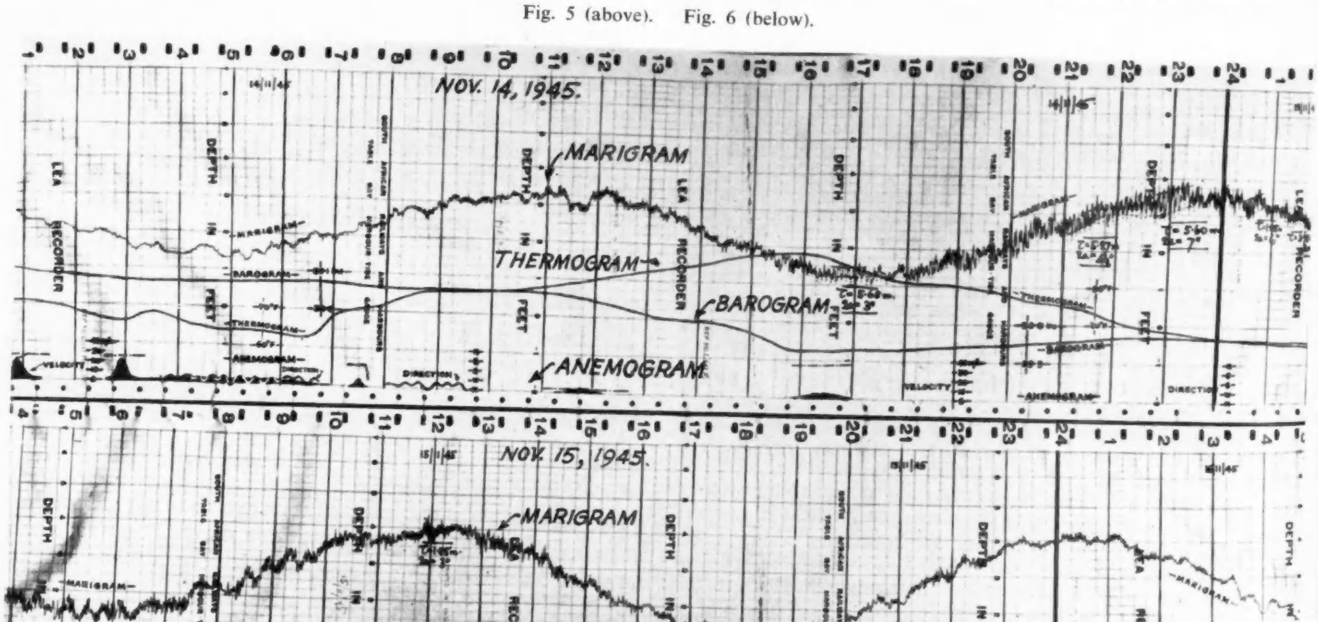


Fig. 5 (above). Fig. 6 (below).



Oscillations of the Sea and the Phenomenon of Range—*continued*

factor that can be identified as an infallible link between Range-action and *local* weather. The principal anomalies are:

(1) Barometric pressure-sags at Cape Town are not always a reliable index of the incidence of Range. The latter is found to lag behind a pressure sag in some cases and precede it in others, and instances have been quite numerous where Range developed while barometric pressure at Cape Town was high.

(2) Strong local winds from the north-west (the open sea) are also not a dependable criterion for expecting the onset of Range. The phenomenon often occurs in periods of absolute calm.

(3) Apart from a minor influence of the semi-diurnal tide upon the transverse oscillations in the Duncan basin, amounting to a slight increase in amplitude at every high tide, there is no obvious connection between Range and tide. Range-action occurs as often at neaps as at spring tides.

Detailed scrutiny of particular occurrences of Range-action, of which Figs. 5 and 6, depicting marigrams for the Duncan Basin (with superposed baro-, thermo- and anemograms), may be considered as representative, failed to resolve the above anomalies. Their explanation therefore demands a certain amount of conjecture.

It is entirely possible that Range (deriving from purely meteorological sources) may be born of several distinct causes associated with travelling depressions, each of which may operate independently or in unison with the others. We may thus venture to propose at least two plausible hypotheses for modes of generation to account for the Range phenomenon and explain away the difficulties, namely:

(a) Generation by Air Waves (Barometric and Anemometric.)

Here it is believed that air waves are a common feature of barometric depressions and are frequently to be found along the marginal interface defining the cold front, itself an atmospheric wave. By means of fluctuating vertical pressure and wind traction of the surface of the sea, it is supposed that these air-waves generate sea-waves or swell with a wide range of periodicities, including visible surface-waves and invisible ground-swells. The long arm of the cold front of a depression, in terms of this concept, acts as a broom in sweeping sea-waves before and behind it.

(b) Generation by the Exhaustion of Depressions.

A travelling depression of some intensity elevates the surface of the sea beneath it. As long as the depression moves forward slowly or varies gradually in intensity, it is possible for the entrained body of water to conform with the rate of change by rising or dispersing, as required, in weak currents. It is possible, however, to visualize every sudden intensification, cessation of forward movement, or exhaustion, of a depression, caused by a recession or inrush of neighbouring anti-cyclones, such that the normal stability of the elevated water mass is upset. Long waves in such circumstances would almost inevitably develop in conjunction, no doubt, with shorter swells from increasing or dying winds, as the case might be; these would tend to radiate outwards from the depression centre.

REFERENCES

22 "Sea Waves," Dock & Harbr. Auty., Jan., 1942, pp. 45-48.
23 "Ocean Swells and Abnormal Tides", Engineering, Oct., 1937, pp. 406-8.
24 Proc. Inst. C.E., Vol. 209, 1919, p. 244.
25 Munk, Inglesias & Folsom, "An Instrument for Recording Ultra Low Frequency Ocean Waves", Rev. of Sc. Instru., Vol. 19, Oct., 1948, pp. 654-658.
26 "Surf Beats", Trans. Am. Geophys. Union, Vol. 30, Dec., 1949, pp. 849-854.
27 "Surf Beats: Sea Waves of 1 to 5 Min. Period", Proc. Roy. Soc., Lond., Ser. A., Vol. 202, Aug., 1950, pp. 565-573.
28 "Ocean Waves and Swell", Published Lecture, Maritime & Waterways Eng. Divn., Inst. C.E., 1950.
29 Cf. Lacey, "The Coromandel Coast of South India", Dock & Harbr. Authy., Dec., 1943, and Feb., 1944, p. 181 et seq.
30 "Destructive High Waves along the Southern California Coast", Shore & Beach, April, 1935.
31 "California Seiches and Philippine Typhoons", Proc. United States Naval Inst., Vol. 63, 1937, pp. 775-788.
32 "Abnormal Tides in the Thames", Engineering, Aug., 1936, p. 178; also "Ocean Swells and Abnormal Tides", Engineering, Oct., 1937, pp. 406-8.
33 Cf. Proc. Inst. C.E., Vol. 209, 1920, pp. 189-250. See also Minikin, "Winds, Waves and Maritime Structures" (London), 1950, pp. 135-145.
34 "Design and Construction of Harbours" (Edinb.), 1864.
35 Proc. Inst. C.E., Vol. 209, 1920, pp. 178-250.
36 "Mouvement de Seiche dans une Baie", Rev. Gen. de l'Hydraulique, Jan., 1938, pp. 3-6.
37 "California Seiches and Philippine Typhoons", Proc. U.S. Naval Inst., Vol. 63, 1937, pp. 775-788; also "San Francisco Bay Tides", Proc. U.S. Naval Inst., Vol. 65, 1939, pp. 1270-1276.
38 "Hydraulic Research in the United States", U.S. Dept. Commerce (Washington), Vol. XI, 1947, and subsequent issues.
39 Trans. ASCE., Vol. 110, 1945, p. 357
40 Cf. Abecasis, "Le Port de Leixoes (Portugal)", Communication 4, 17th International Navigation Congress (Brussels), 1949, pp. 186-200.
41 Report by Orego and Santander, ibid, pp. 23-30.
42 Cf. Paterson, "The Sturrock Graving Dock, Cape Town", Proc. S.A.Soc.C.E., Vol. 45, 1947, pp. 64-67; and discussion, pp. 180-183.
43 "Range-Action in Harbours", Jour. Inst.C.E., Jan., 1943, p. 192.

(To be continued)

Indonesian Port Facilities

Reconstruction and Expansion Works in Hand

Considerable port and harbour reconstruction and expansion work is at present being undertaken in Indonesia according to a recent statement by Mr. van Banchet, Director of the Harbour Department of the Ministry of Communications, who recently outlined plans to increase port facilities.

Particular attention is being paid to and Tandjong Priok, the harbour for Djakarta, and endeavours are being made to rationalise trading procedure so that foreign companies need not have vessels unloading at one port and then going to another to take on cargoes. Development in this respect is facilitated by the fact that the main trading companies operating in Indonesia are domiciled at Djakarta.

Before the war Tandjong Priok mainly catered for large foreign ocean-going vessels and KPM inter-island craft. After the war, coasters, as well as the larger vessels created the need for berths suited to their requirements. These are now under construction together with the necessary warehouses and other facilities. Also under construction is a special dock for handling timber and a quay for the Marine Police Force. Special equipment designed to facilitate the work of the lighters is also being installed.

Lengthening of the main wharf at Tandjong Priok began last year and is scheduled for completion in 1953. Other parts of the harbour are also to be extended and deepened. This will involve the removal of sunken vessels blocking the channel, which are relics of the war.

Warehouses built at Tandjong Priok during the last two years have increased the port's storage space to 14,000 square metres. The new warehouses for coasters, which are expected to be completed in 1954, will cover an additional area of 8,000 square metres. Plans are also being made for the building of oil storage tanks.

In co-operation with the Ministry of Public Works and the Djakarta Municipality, the Harbour Department is draining swamps between Tandjong Priok and Kemajoran. This project is being carried out within the framework of a ten-year plan to build port warehouses, factories and houses in the region. Work is being undertaken by means of several dredgers which have already been delivered as part of a number now on order.

Although, it is claimed, as regards technical equipment Tandjong Priok compares favourably with most Asian ports, the turn-round of shipping is slow. It takes longer to clear a vessel at Tandjong Priok, compared with many Japanese and European ports. This, in the opinion of the Director of the Harbour Department, is due to the short working day in Indonesia and the frequency of holidays.

Expansion being undertaken at other ports includes warehouse construction at Belawan and the erection of landing stages at Telukbajur, while new port facilities, estimated to cost Rp. 45 million, are now under construction at Bitung, Minahasa.

Nigerian Ports Authority

Statement of Proposed Policy

On August the 18th, 1952, it was announced in the House of Representatives that the Nigerian Government had agreed in principle on the establishment of a Ports Authority empowered to take over, at such times and in such manner as the Governor in Council might direct, not only all ports at present operated by Government but also all other ports in Nigeria. It was at the same time announced that the Ports Authority would take the form of an autonomous statutory corporation.

In September Mr. C. A. Dove, M.B.E., was appointed as General Manager (Ports) with, amongst other duties, the specific tasks of planning the organisation of the Ports Authority and of assisting in the drafting of the necessary legislation. His proposals have received prolonged examination by Government, the conclusions of which are the subject of this statement.

It has been decided that the new Ports Authority should, in the first instance, limit its wharf operations to Port Harcourt and to Apapa and Customs Wharves in Lagos, on the purely practical ground that the Authority will not have built up the necessary organisation to take over the administration of all ports simultaneously. The two major ports of Port Harcourt and Lagos handled between them last year 78 per cent. of the total tonnage of sea-borne trade and 88 per cent. of imports. The lesser ports will be taken over as occasion serves.

Constitution of the Ports Authority.

A Ports Authority can be defined as a Public Trust or Corporation with an element of self-administration in that the payers of dues are permitted to nominate their own representation on the Board. It is a body corporate with perpetual succession and a common seal. For Nigeria it is proposed that the Corporation shall consist of a Chairman, who would also be the Chief Executive, together with a Board of ten members. The Chairman would be responsible for the day to day management of the ports in accordance with directives laid down by the Board.

Jurisdiction and Powers of the Ports Authority.

For practical purposes a single Ports Authority will fully meet the economic needs of Nigeria for many years to come, although it is recognised that, as trade expands and the general development of the country proceeds, further consideration may one day have to be given to the possibility of setting up more than one authority.

The Ports Authority will, on establishment, take over all those statutory duties at present imposed on the Marine Department as Harbour Authority, Lighthouse Authority and Pilotage Authority in Nigeria and the Cameroons. In addition it will assume the responsibility for licensing water-frontages in so far as those duties rest at present with the Marine Department. Similarly, the Authority will take over the duties of the Railway, Customs and Public Works Department in so far as they concern the operation, administration and maintenance of wharves transferred to it. In order to operate efficiently as an autonomous, statutory corporation, the Ports Authority will require certain additional powers above those already enjoyed by these Departments, especially in the fields of finance and business operations, the more important aspects of which will be subject to the approval of the Governor in Council. These powers will be defined in the Bill to be submitted to the House of Representatives.

The administration of the two principal ports, Lagos and Port Harcourt, has hitherto been divided between the Railway, the Marine and Customs Departments—the latter in so far as Customs Wharf Lagos alone is concerned. It will accordingly be necessary to transfer various services and capital assets, provided by these Departments and which have hitherto formed part of the Departmental accounts, to the new Authority. The Nigerian Government has accordingly decided to engage a firm of Consulting Accountants to assess the value of capital assets to be transferred to the Authority, to advise on the accounting of Railway and Marine services to be taken over by the Authority and finally to assess the present financial position of port operations in Nigeria. The Consultants' report will determine whether or not the Ports Authority can be made self-supporting from the outset. The objective of establishing a fully economic Authority must, however, remain a primary consideration and it is intended that this shall be realised with the minimum of delay.

Transfer of Railway Assets.

At present Apapa Wharf and Port Harcourt are Railway Ports operated by Railway staff and financed from Railway funds. The transfer of Railway assets, which will include some rolling stock and staff as well as fixed installations, to the new Authority will require meticulous planning in great detail but a preliminary examination of the problem indicates that there should not be any major obstacle to effecting the transfer smoothly and without interruption of the normal flow of overseas trade.

Port Labour Force.

Contract labour in Nigeria is largely "casual" with the result that contractors find it difficult to standardise shore-handling methods and quite impossible to give the specialised training required in certain fields of modern port working. By employing its own labour a Ports Authority will be in a position to begin the stabilisation of its labour force, a necessary condition to any form of training and standardisation. At the same time the Authority will be able to train men in the mechanised handling of cargo and to grade them for advancement to more responsible jobs for which there should be scope in a modern port. The gains to efficiency which may be expected from unified control are self-evident but it should be added that, apart from its advantages to the port administration, direct control should also bring about a reduction in the pilferage of cargo now common on wharves and in warehouses.

Inland Waterways.

Nigeria possesses an extensive system of inland waterways, access to which is restricted by the changing shoals and other obstacles to navigation in the seaward approaches to the ports. Although the rivers already carry considerable traffic, any major expansion of river trade above its present level must in the last resort depend on providing secure deep-water access to the delta and creek ports where cargo is transhipped to sea-going vessels. Government has recently engaged the services of the Netherlands Engineering Consultants to conduct an intensive investigation into the problems of the ports lying between the Benin and Ramos Rivers and this limited scheme, if successful, will be followed by similar investigations elsewhere. In particular, Government has agreed in principle to an examination of the Niger as far as Baro and of the Benue at least as far as Yola. It is Government's intention that the Ports Authority should in due course examine the possibility of taking over wharf responsibilities in the river and delta ports within the area of its jurisdiction in addition to the harbour duties which it will assume on establishment.

Nigeria Marine.

It is of the utmost importance that the Ports Authority should, for efficiency, have full control over its own seaward approaches and entrances and harbours. Government has accordingly decided at the start to place the Nigeria Marine in its entirety under the Ports Authority. In order, however, to maintain the essential services within the inland waterways, as well as to equip the Ports Authority with the powers required for its task, it will be necessary to modify to a limited extent the present organisation of the Department when it is taken over by the Authority. The changes will be based on the following principles:—

(i) The Ports Authority will assume and finance those functions of the Marine Department which can properly be defined as those of a Ports Authority and chargeable to Port Revenue. For the convenience of Government, the Authority will maintain and operate all other existing Marine services on reimbursement by Government.

(ii) The Ports Authority will from the date of its establishment administer the Nigeria Marine so that the services not specified as properly those of the Authority can be separately accounted for.

(iii) The Ports Authority will gradually reorganise the Department with the object not only of maintaining separate accounts, but also of furthering the ultimate creation of an Inland Waterways Section within the Department. If, however, the development of these waterways, on a scale large enough to justify a separate Government department, should prove impracticable, then the Inland Waterways Section will remain a part of the Marine Department of the Authority.

The Corrosion of Iron and Steel and its Prevention

With Special Reference to Harbour and Dock Installations

By J. C. HUDSON, D.Sc., D.I.C., A.R.C.S., F.I.M.
(British Iron and Steel Research Association)

(*continued from page 84*)

4. How to Prevent Rusting.

4.1. General Principles.

(i) **Cheap protective schemes may be a false economy.** It is a regrettable fact that there still exists considerable ignorance of the most effective methods of preventing rusting. Moreover, even when these methods are known, there is sometimes a reluctance to put them into practice because of their apparently greater cost. It cannot be too strongly emphasised that, if true economies are to be achieved, it is essential not to think solely in terms of initial expenditure but rather to budget for the most efficient and cheapest method of protecting the steelwork during the whole of its desired service life. This principle is well illustrated by the hypothetical case of a 300-ft. by 120-ft. shed considered by Mr. Ordman in his introductory article. He estimates that the cost of 18G sheeting for such a shed would be about £9,000 in plain steel or £12,000 in galvanised steel and that the cost of painting the sheeting would be about £3,000. It is clear that the more expensive galvanised sheets would prove the more economical in the long run if their use made it possible to dispense with slightly more than a single painting. As several years could be allowed to elapse before the galvanised sheets were painted at all and as, moreover, the life of a painting scheme should be much longer over a weathered galvanised surface than over rusty steel, it is highly probable that this economy in painting would be achieved.

The Golden Gate Bridge at San Francisco is a good practical example of the cases where a slightly more liberal outlay on the initial protective scheme would have been amply recouped by material reductions in the subsequent maintenance costs. Sand-blasting was proposed as the method of preparing the steelwork for painting but was rejected on the grounds of economy. So the steel was prepared by solvent-cleaning and wire-brushing and painted with up to three coats of paint in the shop. But, by the time the steel had been shipped through the Panama Canal and reached its destination, this shop paint had deteriorated badly, because of the loosening of the millscale underneath it. In many places complete repriming was necessary. Failure of the paint through this cause continued during the erection of the bridge and long after it had been opened to traffic in 1937. The total annual cost of paint maintenance during the ensuing two or three years

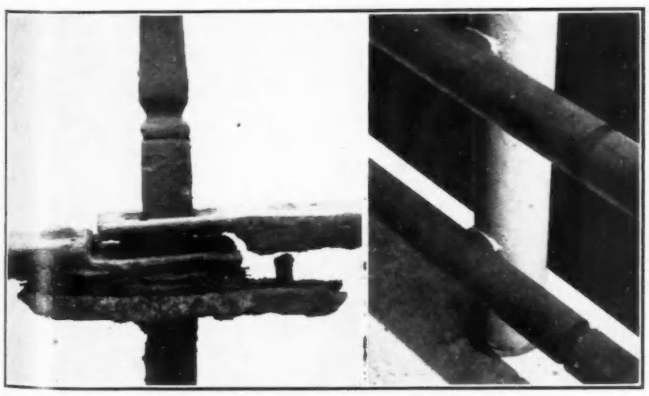


Fig. 16. **Effect of Design on Corrosion. Railings at Westminster Abbey (left) and on Waterloo Bridge (right).** The lapped joints of the Westminster Abbey railings, erected in 1746, have proved a source of weakness. Heavy rust scale has formed inside them and burst the bolts. The cleaner design of the Waterloo Bridge railings (1945) affords little opportunity for rusting due to local lodgement of dust and moisture.

Fig. 17. Effect of Design on Corrosion. St. James's Park Footbridge. The accumulation of moisture and dust in the laps of the lattice work and in the open box-like sections has led to the rusting through of some of the side railings of this bridge, which dates from 1857.

was well over 100,000 dollars. In fact the condition of the paint became so unsatisfactory that it was decided, in order to put matters right, to use flame-cleaning to remove most of the paint previously applied and then build up the painting scheme anew. To carry out this plan, it was necessary to erect four permanent movable scaffolds at a cost of nearly 40,000 dollars. This treatment seems to have made a good job of the protective scheme at last.

It is easy to be wise after the event and about 20 years have elapsed since the Golden Gate Bridge was projected. Yet if practical effect had been given to what was already known scientifically at the time, much of the heavy expenditure incurred on maintenance painting could have been avoided. By contrast, as indicating the best modern procedure, reference may be made to the protective scheme adopted at the new Abbey Works of the Steel Company of Wales Ltd. for all the steelwork above the level of the crane runway. More than 15,000 tons of steel were involved. The whole of this was grit-blasted and then sprayed with aluminium to a thickness of 0.004-in. A single coat of aluminium paint was applied over the aluminium. It has been estimated that the cost of this treatment per unit area was not more than 2¼ times that of the more conventional method—three coats of paint on a weathered and wire-brushed surface—used for the rest of the steelwork and that the total cost of protective treatment over a period of 50 years for the metal-sprayed work should be just under half of that for the other steel painted in the usual way. This is because the necessary intervals between repaintings should be appreciably longer when paint is put on over the aluminium coating.

(ii) **Importance of correct design.** It has truly been said that the prevention of corrosion begins on the drawing board. This means that in designing structures care should be taken to avoid all details that may serve to aggravate corrosion, such as badly designed joints or laps that retain moisture and grime in contact with the steel; two examples are shown in Figs 16 and 17. Another obvious, yet surprisingly common error is to design a structure in such a way that parts of it are inaccessible for painting. It is equally necessary to avoid placing steel in contact with corrosive

Corrosion of Iron and Steel—continued

building materials or, where electrochemical corrosion is possible, with dissimilar metals. Thus it is unwise to lay timber directly on to steel, and it is bad practice to mix galvanised and copper pipes or equipment in water installations.

(iii) **Methods of preventing corrosion.** The methods available for preventing corrosion can be classed under the following four headings:

1. Treatment of the corrosive medium, so as to render it non-aggressive.
2. Cathodic protection.
3. Use of corrosion-resistant materials.
4. Use of protective coatings.

4.2. Treatment of the Corrosive Medium.

The prevention of corrosion by treatment of the corrosive medium involves air-conditioning in the case of atmospheric corrosion and the use of inhibitors in that of aqueous corrosion. Treatment of the atmosphere on a large scale is clearly impracticable but, for certain special applications, where the value of the exposed steel warrants it, air-conditioning will prove a successful and economical remedy. The most modern needle factories are equipped with plant that warms and dries the air in their finishing and packing shops, so that the polished needles are not exposed to the danger of rusting. Similar equipment is being installed in oil tankers, with a view to reducing the heavy corrosion often experienced by the steel walls and bottoms of the tanks.

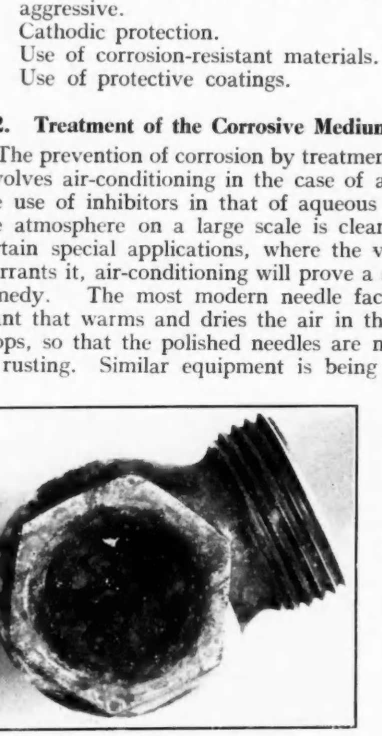


Fig. 18. Fitting from Domestic Hot-Water System blocked by Rust.

The use of inhibitors to prevent aqueous corrosion is a vast subject, which need not be discussed in detail as it is rather outside the practical field to which this article is primarily devoted. It may be illustrated by a case studied by the author in which trouble from corrosion was experienced in a domestic hot-water system. Leaks developed in the galvanised hot-water cylinders and pipes after they had been in service for about 11 years; in places the pipes had become plugged with corrosion products (Fig. 18). Investigation showed that the corrosion had been aggravated in its later stages by the use of copper pipes to replace old galvanised iron pipes that had begun to leak. This is inadvisable, because small amounts of copper are dissolved by the water and re-deposited on the galvanised parts of the pipe line, thus setting up local electrolytic corrosion cells of copper and zinc, in which the zinc coating on the galvanised pipes is attacked. Experiments were made in the hot-water system itself on the effect of adding sodium silicate to the water as an inhibitor. The results showed that the addition of 20 parts per million of sodium silicate reduced the corrosion considerably and the possibility of treating the water at the source in this way is now under consideration.

It may be found that inhibitors are also of value in reducing soil corrosion, as investigators at the Chemical Research Laboratory have recently observed that the activities of sulphate-reducing bacteria are depressed by certain substances, such as tannic acid.

4.3. Cathodic Protection.

(i) **Theory.** The train of reasoning on which cathodic protection is based is simple and may be expressed thus: " Corrosion is an electrochemical process involving an anode, which is corroded, and a cathode, which is not. Let us, therefore, so arrange matters that the metal that we wish to protect acts as a cathode, i.e. is the uncorroded member of the electrolytic cell." This is the basis of the old practice of fixing " zincs " in the neighbourhood of non-ferrous metal fittings in the hulls of ships, which would otherwise cause severe corrosion of the steel plates in their vicinity.

In essentials, therefore, cathodic protection consists in making the steel the protected part of a suitable electric circuit, so as to throw the corrosion from it on to a " sacrificial anode." This anode may be of some metal less noble than iron; the most suitable for the purpose is magnesium lightly alloyed with nickel. In this type of assembly the circuit generates its own current. Alternatively, the protective current needed may be supplied from an external source of electrical energy; in this case anodes of scrap iron or steel or of other materials, such as graphite, are used.

(ii) **Practical applications.**

It is obvious that cathodic protection can only be effective when the system to be protected is in contact with a good electrical conductor. This condition is amply satisfied when steel is immersed in sea-water or buried in most types of soil.

Cathodic protection should, therefore, prove extremely useful to engineers interested in docks and harbours, where ample opportunities exist for its application, and in fact it is being effectually used to an increasing extent for preventing the corrosion of immersed structures. It has, for example, been successfully applied to the lock gates of the Panama Canal. Each practical case is a study in itself and it is advisable to consult experts with previous experience in the field. It may, however, be of interest to present briefly the results of some calculations made by Mr. W. E. Ballard and the author with reference to the cathodic protection of a steel landing stage, as these give an indication of the order of the magnitude of the cost of the method.

The total area of immersed steel in this landing stage was 7,200 sq. ft. It is generally believed that a current density of 4-5 milliamps per sq. ft. is sufficient to protect steel cathodically, but, if a value of 10 milliamps per sq. ft. is assumed, so as to provide a margin of safety, a current of 72 amps would be needed to protect the structure. Consequently, the problem was how to supply this quantity of electricity, which amounted to about 24,000 faradays per year, to the structure most economically. Two methods of doing this were considered, (a) by means of an imposed current from a suitable generator, scrap steel anodes being used, or (b) by means of magnesium-alloy anodes. If both iron and magnesium are assumed to corrode away in the divalent condition, one faraday will consume about 1 oz. of iron or 3/7 oz. of magnesium. So the weight of metal sacrificed per year would be roughly 1,500 lb. for scrap steel anodes or 650 lb. for magnesium-alloy anodes.

After due allowance for the cost of the auxiliary equipment, materials and services, it was deduced that protection by an imposed current would cost about £200 per year and protection by magnesium anodes about £300 per year.

No great accuracy can be claimed for these estimates and it may be that they would have proved rather wide of the mark. Certainly no importance should be attached to the fact that the results make the use of magnesium anodes appear more expensive than that of scrap steel anodes. The relative costs of the two processes will vary according to the local circumstances. The main lesson to be learnt from these hypothetical calculations is that cathodic protection is comparatively cheap. If we divide £200, or even £300, by the total area of the landing stage, 7,200 sq. ft., the cost of cathodic protection works out at only 7d. or 10d. per sq. ft. per annum. In practice the cost would probably prove less, if, as would be desirable, the usual protective coating of bitumen were applied to the piles. This would reduce the area needing cathodic protection and, therefore, the current consumption. Moreover, the precipitation of the protective film of calcium and magnesium salts at the cathodes, as described in section 3.2, would have the same effect. It may be remarked here that, wherever practicable, cathodic protection is best used in conjunction with the usual protective coatings rather than as a substitute for them. This is particularly true of buried pipes, where the purpose of the cathodic protection should be to prevent corrosion at weak spots in the protective bitumen coating.

The figure of 7d. to 10d. per sq. ft. given above for the cost of cathodic protection seems to be of the right order of magnitude, because E. P. and G. L. Doremus[8] report that in their experience

[8] E. P. Doremus and G. L. Doremus. "Cathodic Protection of Fourteen Offshore Drilling Platforms." Corrosion, 1950, July, 216.

Corrosion of Iron and Steel—continued

of cathodic protection of oil-drilling platforms erected at some distance offshore in the Gulf of Mexico, the cost amounts to about 5d. per sq. ft. over the first two years and should decrease thereafter to about 3½d. per sq. ft. The method used consists in providing sufficient permanent magnesium anodes to give a steady current of about 2.5 milliamps per sq. ft. At first these anodes are supplemented by cored magnesium ribbon, which is hung in the water in 25-ft. lengths. The object of the ribbon, which is sacrificed during the first few days, is to provide a high initial current density, about 100 to 200 milliamps per sq. ft., so as to ensure the deposition of calcium and magnesium salts from the sea-water. After this has taken place, the permanent anodes take over the work of protection and the current density is adjusted to the necessary value by means of a resistance inserted at the head of each lead to an anode.

The platforms in question have a totally submerged steel surface of about 23,000 sq. ft. Rather more than a ton of magnesium alloy is needed to protect them for two years. This is provided in the form of about 40 permanent anodes of 50 lb. each plus the wire used up in the first few days.

4.4. The Use of Corrosion-Resistant Materials.

The effects of the composition of iron and steel on their resistance to corrosion by air, water and soil have already been discussed in section 3, and it only remains to consider briefly how this information can best be applied to practical advantage.

It is improbable that the highly-alloyed rust-resisting steels will ever find wide application for general structural purposes within harbours and docks. These steels are necessarily expensive but more important still, their output must be limited. The annual production of steel in the United States and Great Britain alone exceeds 120 million tons. To make all this steel of rust-resisting quality of the 18/8 chromium-nickel type, about 10 million tons of nickel would be needed. But the world output of nickel is only of the order of 200,000 tons per year and there are many other uses for it. So it is clear that the use of rust-resisting steels must largely be restricted to special applications, such as plant for the chemical industry.

The use of low-alloy steels offers much more practicable possibilities. As these contain at most two or three per cent. of alloying elements, they are not unduly expensive and their potential output is not severely limited by the availability of materials. One of the best low-alloy steels now on the market is only one-third dearer than ordinary mild steel and it could be expected to resist corrosion in the open air up to six times better than the latter.

As will have been gathered from section 3, the use of low-alloy steels for combating corrosion will yield the maximum advantage in the case of structures exposed to atmospheric corrosion. As yet insufficient use is made of low-alloy steels for structural purposes in our country and it would be to the national advantage to use them more widely. Their value, has fully been confirmed by practical experience. For example, service trials made by the British Iron and Steel Research Association in conjunction with British Railways have already demonstrated that the floor plates of steel coal wagons will last at least twice as long if they are made of low-alloy steels instead of ordinary steel.

It is particularly desirable that articles of thin section, such as fencing wires and roofing sheets, or structures that for any reason cannot be maintained by painting should be made of low-alloy steels. As a simple example of the advantages to be gained thereby, the following estimates of the lives of non-galvanised bare steel fencing wires in a marine atmosphere may be considered. The figures are based on actual experimental data and two sets are given, for ordinary steel and for copper-steel, which contains about 0.3 per cent. of copper and is the simplest low-alloy steel; more complex low-alloy steels would last appreciably longer than copper-steel.

Gauge S.W.G.	Diameter In.	Life to Failure. Years. Ordinary Steel.	Copper-Steel.
16	0.064	4	5
14	0.080	7	9
12	0.104	11	14

Low-alloy steels do not show to particular advantage as compared with ordinary steel when they are totally immersed in water or buried in the soil, although their resistance to corrosion under these circumstances is certainly no worse than that of ordinary steel. They may be slightly more resistant under conditions of intermittent immersion, for then part of the corrosion cycle takes place in the atmosphere.

4.5. Protective Coatings.

Protective coatings for iron and steel may be classed in three groups: paints, metal coatings and sundry coatings.

(1) **Paints.** It is fitting to commence this section with a discussion of painting, which is the most common method of protecting steel and is likely to remain so.

Surface preparation. As Mr Ordman pointed out in his previous article, correct surface preparation is by far the most important factor in determining success in the protection of steel by painting. This has been demonstrated by numerous researches and fully confirmed by practical experience. For example, in some tests by the Corrosion Committee of the British Iron and Steel Research Association the following results were observed for the effective life of a painting scheme, consisting of two coats of red lead in linseed oil paint and two coats of red oxide in linseed oil paint, applied to several different irons and steels exposed to an industrial atmosphere at Sheffield.

Surface Preparation of the Steels for Painting.	Durability of the Painting Scheme. Years.
Weathered and wire-brushed	2.3
Painted over the intact millscale	8.2
Descaled by pickling	9.5
Descaled by sandblasting	10.4

It will be seen that correct surface preparation had the effect of quadrupling the life of the painting scheme. By far the worst performance was obtained when the steel was prepared by the usual method of weathering followed by wire-brushing. Painting over an intact millscale is impracticable for a struture of any appreciable size. So the best method consists in descaling the steel beforehand. This can be done either by pickling or by sand- (or grit-) blasting; there is little to choose between the results obtained by these procedures.

An economical and efficient method of removing the millscale consists in pickling in hot dilute sulphuric acid and then giving the steel a dip in hot dilute phosphoric acid, as in the following process, developed by Dr. H. B. Footner.

Sulphuric acid bath. The initial concentration of sulphuric acid is 5 per cent. and the temperature is maintained at 60-65°C. It should remove the millscale from the steel in about 15-20 minutes and should be replenished with additions of concentrated acid when pickling becomes sluggish. When it contains 6 per cent. of iron, the bath should be renewed.

Hot-water rinse. On leaving the sulphuric acid bath, the steel is held for about half a minute, to allow the acid to drain from it, and is then dipped twice in a water bath at 60-65°C.

Dilute phosphoric acid bath. Finally, the steel is immersed for up to 5 minutes in a solution containing about 2 per cent. of free phosphoric acid and 0.5 per cent. of iron held at 85°C.

It is important that the priming coat of paint should be applied to an unrusted surface, whatever method is used to remove the millscale. The Footner process has the advantage of producing a thin phosphate layer on the steel, with a slight but definite resistance to corrosion. Another valuable feature is that the priming coat of paint is put on whilst the steel is still warm, immediately it has dried after removal from the last bath.

One qualification must be made to the statment in the last paragraph that a steel surface should be free from rust at the time of painting. This remark applies essentially to the painting of land structures exposed to atmospheric corrosion. For some reason certain anti-corrosive compositions used for marine purposes do not adhere well to freshly descaled steel. Consequently, when painting ships' bottoms or other structures subsequently exposed to immersion in sea-water, it is an advantage to allow them to rust slightly after they have been descaled and before painting them. Alternatively, treatment with a cold phosphoric wash eliminates any tendency for the paint not to adhere. It might be expected, therefore, that good practical results would be obtained

Corrosion of Iron and Steel—continued

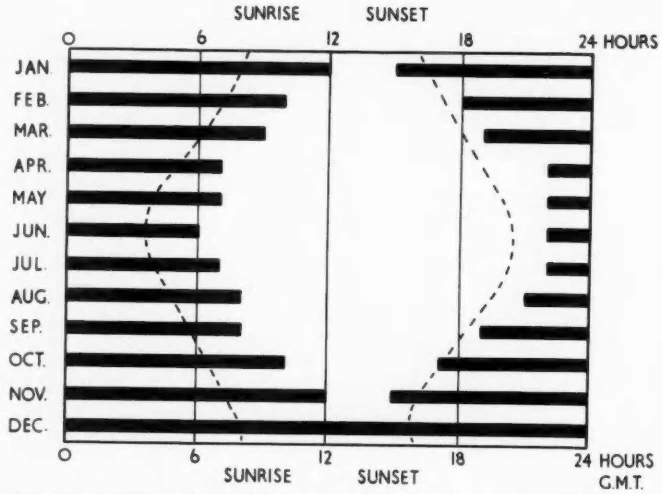


Fig. 19. Variation in the Atmospheric Humidity at Kew Observatory. The black bars show the periods of the day when the relative humidity of the air normally exceeds 80 per cent. and painting should be avoided, if practicable.

when a ship's bottom was prepared for painting by weathering the plates until all the millscale had been shed from them. This in fact is the case, as has been shown by experiment. Unfortunately, modern conditions of shipbuilding are such that it is hardly practicable to weather the plates for a sufficiently long period. It is better, therefore, to descale them by pickling or sand-blasting and treat them afterwards as described above.

The operations of surface preparation and of prime-painting are greatly facilitated if they can take place at the steelworks and certain companies in the United States and in Great Britain have already begun to provide such facilities for their customers. It may be anticipated that this development will spread.

It may be useful to draw attention here to some specifications for the surface preparation of steel for painting that have recently been published by the (American) Steel Structures Painting Council[9]. These cover solvent cleaning, hand cleaning, power tool cleaning, flame cleaning, blast cleaning (three different grades of finish), pickling, and weathering and cleaning. They are a valuable guide to current good practice in the processes mentioned and are to be followed by other sets of specifications for pretreatment (e.g. wetting oils and surface washes), paints and painting schemes for structural steel.

Priming paint. The factor next in importance to surface preparation in determining the success of protective painting of steel is the choice of the priming paint. Research and experience have shown that the best results are achieved by using priming paints with inhibiting properties, i.e. paints that exert a passivating effect on the steel and do not merely exclude the corrosive agents. Red lead in linseed oil is the standard example of an inhibitive paint, as compared with say, red oxide in linseed oil paint, which protects steel solely by shielding it from air and moisture.

Researches by the British Iron and Steel Research Association have shown that for the protection of atmospheric structures priming paints bound in linseed oil media are as good as any and that few pigments give better results in this medium than red lead. For practical purposes, however, the working and storage properties of the paint can be improved if some other pigment is substituted in part for red lead. White lead is particularly useful for this purpose and a formulation on the following lines is a good all-round priming paint for structural steelwork.

	Weight per cent.
Red lead	32
White lead	32
Asbestine	16
Refined linseed oil ...	14
Boiled linseed oil	4
White spirit	1
Driers	1

The details of this formulation are not critical. The object should be to produce a paint with easy working properties whilst maintaining a high pigment/vehicle ratio of the order indicated.

Priming paints of this type require a reasonable drying period and it is inadvisable to overcoat them with oil paints in similar media within 24 hours. Much longer drying periods are needed when bituminous or tar overcoats are to be used; in such cases the priming paint should be left for a fortnight, and if possible longer, before the next coat is put on. A desirable development in paint technology is, therefore, to produce a priming paint of the red lead type that could safely be overcoated with bituminous paint after the normal drying period overnight. It is essential, however, that this improvement should not be at the expense of the inhibitive properties of the red lead paint. J. E. O. Mayne[10] has shown that these depend on the formation of lead soaps as a result of reactions between the pigment and the linseed oil medium. Clearly, any alteration in the medium that prevented this soap formation might jeopardise the valuable inhibitive properties of the paint, so that an improvement in compatibility with bituminous paints might be dearly bought if this were done at the expense of inhibitive power.

Finishing paint. If the steel surface has been properly prepared and properly prime-painted, the selection of the subsequent coats of paint is not a critical matter and a wide range of materials is available. For industrial purposes red oxide in linseed oil paints or bituminous paints are suitable; paints pigmented with aluminium powder or micaceous iron ore have also found wide application. Some of the new media, such as the alkyds and the phenolics, undoubtedly have better weather resistance than the older linseed oil media. Against this should perhaps be placed the fact that when a paint in a synthetic medium fails it may do so by flaking, whereas paints in linseed oil media fail by gradual chalking and erosion of the paint film. It may, therefore, be that although the newer paints have the longer durability, they yield a surface that needs more preparation when the time comes for repainting. This is certainly true of ordinary house-painting, where one factor has to be balanced against the other, but the author cannot say how far it applies to the painting of structural steel.

Painting of steel for under-water service. Although a mixed red lead and white lead in linseed oil paint, as described above, will give reasonably good results on steel that is to be immersed in fresh or salt water, particularly if it is allowed a long drying time before immersion, it is not the best for the purpose. Here it is undoubtedly of value to use paints in synthetic media. This is because, unless the protection yielded by the paint film is perfect and remains so, electrolytic corrosion of the steel is liable to occur, particularly in waters of good electrical conductivity such as sea-water. As described in section 2.3, the ensuing reactions result in the formation of alkali at the cathodes and there is a corresponding development of acidity at the anodes. Consequently, as the French investigator G. Dechaux[11] has demonstrated, anti-corrosive compositions on ships' bottoms have to be able to withstand highly acid conditions (pH4) and highly alkaline conditions (pH11), to either of which they may be subjected locally. Linseed oil is particularly sensitive to alkalis, which hydrolyse or saponify it, and is, therefore, markedly inferior for the purpose under discussion to synthetic media, which are much more chemically inert. Two of the best types of such media are the chlorinated rubbers and media based on unmodified phenol-formaldehyde resins. The latter have found considerable application in the specifications of the U.S. Navy. The development of chlorinated rubber paints has been retarded by the fact that they are difficult to apply and have poor storage properties but these difficulties have been overcome to a large extent by individual paint manufacturers and several good proprietary brands are now on the market.

---

[9] See reference 14 of the Bibliography (Section 6.3).

[10] J. E. O. Mayne: "The Protective Action of Lead Compounds". Journal of the Society of Chemical Industry, 1946, 65, 196.

[11] G. Dechaux: "The Protection of Steel Hulls by Painting." Peintures, Pigments, Vernis, 1942, January, 251; October, 732; November, 758.

Corrosion of Iron and Steel—continued

The British Iron and Steel Research Association has done much research on anti-corrosive compositions for ships' bottoms and underwater use. As a result, several reliable formulations have been developed and their value has been fully confirmed over a number of years by practical experience. The general formulations of three of the best of these compositions are given below.

Anti-Corrosive Composition No.	Formulation Pigment.	Medium.
173	X	A
185	Y	A
655	Y	K1

Pigmentation.	Weight per cent. X	Y	Medium.	
Basic lead sulphate	40	40	A	Modified phenol-formaldehyde/stand oil.
White lead ...	20	—		
Aluminium powder	—	20		
Burntisland red ...	20	20	K1	Modified phenol-formaldehyde/stand oil/tung oil. (Ratio of oils 1 : 1)
Barytes	20	20		

(Burntisland red is a pigment prepared from the residue left after the extraction of aluminium from bauxite; a red oxide pigment, such as Indian red, can be substituted for it without disadvantage.)

The first of these compositions, No. 173, has been adopted with slight modifications by H.M. Admiralty for use as a standard anti-corrosive paint for the bottoms of new construction. It and the other two compositions are also being used with satisfaction in the merchant navy. Trials on large merchant ships have shown that No. 655 is the best of the three but all of them should protect steel immersed in sea-water satisfactorily for twelve months, if applied at adequate coating thickness (see below).

Anti-fouling compositions. The use of anti-fouling compositions is probably not of major importance in docks and harbours, for stationary steel structures, such as jetties, can be allowed to foul without serious damage and the small craft used in harbours can be slipped without difficulty at sufficiently frequent intervals for cleaning their bottoms. It will suffice to remark that the action and formulation of anti-fouling compositions are now much better understood, as a result of researches in Great Britain and the United States during the second world war. Those particularly interested in the subject are referred to a recent monograph compiled by the Woods Hole Oceanographic Research Institution[12].

Other factors. Brief mention may be made of three other factors affecting the protection of steel by painting.

1. It is essential that an adequate cover of paint be built up all over the steel surface. Broadly, it may be said that, using the types of paint at present available, no important steel structure should go into service carrying a paint film less than 5 mils (0.005-in.) thick. In practice this involves the application of three of four coats of paint, as is usually specified for important work by consulting engineers.

For the protection of ships' bottoms and immersed steel, it is desirable to build up a thickness of at least 7 mils of paint on the steel. There is considerable erosion of the paint by the water and, for this reason, painting in service must be such as to maintain the paint film at this minimum thickness. Consequently, it may be a mistake to be contented with giving a ship's bottom a touch-up of anti-corrosive composition instead of a full coat, because the old paint still seems to be in good condition.

2. In general, provided that the paints are correctly formulated for their respective uses and are applied properly under good conditions, brush-painting and spray-application are to be regarded as equivalent—also assuming, of course, that the final dry paint films are of the same thickness.

3. Within practical limits every endeavour should be made to choose propitious weather conditions for painting. It is clear from Fig. 19, for example, that in Great Britain the most favourable conditions will generally occur in the period between May and September. Indoor painting can, of course, be carried out satisfactorily at any time if the shop is properly warmed. This is an additional advantage that accrues from equipping steelworks with facilities for the surface preparation and prime-paining of structural steel.

[12] See reference 17 of the Bibliography (section 6.3).

(ii) **Metal coatings.** The two most important metal coatings for the protection of structural steel are aluminium and zinc. Lead coatings are also serviceable for certain purposes and have been used on bridges by the German State Railways. They protect steel well in industrial atmospheres, where an insoluble film of lead sulphate forms on them but do not show to advantage in non-industrial atmospheres where this film does not form. When lead and iron are joined in an electrolytic cell, iron is the corroded member of the couple. Consequently lead coatings are unsuitable for steel to be immersed in water, because the corrosive attack is concentrated at pores in the coating, where intense pitting may occur. The polarities of zinc and aluminium are on the right side of that of iron, i.e. coatings of both these metals tend to protect steel cathodically (see section 4.3).

For underwater use, zinc is superior to aluminium as a coating metal for steel. Tests by the British Iron and Steel Research Association have shown that a coating of zinc weighing 3 oz. per sq. ft. will protect steel against rusting for about 6 years when it is immersed in the sea. Zinc is also a good coating for steel buried in the soil. The U.S. National Bureau of Standards observed that zinc coatings of the usual weight (about 2 oz. per sq. ft.) would protect steel pipes for about 10 years in most soils. This agrees roughly with the results of tests in British soils, in which the following losses of zinc were observed from hot-galvanised steel pipes and flats after 5 years' burial.

Site.	Type of Soil.	Loss of Zinc after 5 Years. Oz. per Sq. Ft.	Estimated Life of 2 oz. Coating. Years.
Benfleet	Alluvial marsh	1.2	8
Gotham	Keuper marl	0.4	25
Pitsea	London clay	0.4	25
Rothamsted ...	Clay	0.3	33

As yet it is difficult to distinguish between the respective merits of zinc and aluminium coatings for protecting steel against atmospheric corrosion. Extensive researches in this field were begun in 1940 by the British Iron and Steel Association and are still in progress. The results already obtained indicate that in the severely corrosive industrial atmosphere of Sheffield steel can be protected against rusting for 10 years by a coating of sprayed aluminium weighing about $\frac{3}{4}$ oz. per sq. ft., by a zinc coating weighing about 3 oz. per sq. ft., or by a lead coating weighing about 3 oz. per sq. ft. The aluminium and lead coatings are about 3 mils and the zinc coating about 5 mils thick.

As previously stated, lead coatings behave relatively less well in marine and rural atmospheres but otherwise the lives of metallic coatings in non-industrial atmospheres are much longer than in

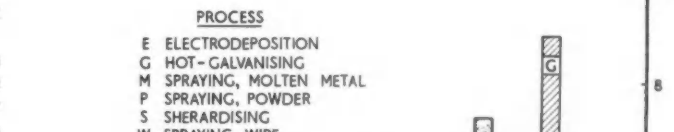


Fig. 20. Effect of Coating Weight and Process on the Protection of Steel by Zinc Coatings. The results relate to zinc-coated steel specimens exposed outdoors in an industrial atmosphere at Sheffield. The point of failure of the coating was taken as corresponding to 5 per cent. of rusted surface.

Corrosion of Iron and Steel—*continued*

industrial ones, so that comparable data are not yet available from these tests for the lives of zinc and aluminium coatings in rural or marine atmospheres. In another experiment, however, hot-dipped coatings of zinc, weighing about 2 oz. per sq. ft., have been exposed on the Welsh mountains at Llanwrtyd Wells since 1930 and still show no sign of breakdown.

At the moment the only practical method of applying aluminium coatings to heavy structural steelwork is by metal-spraying. On the other hand, zinc can be applied by a variety of processes: hot-dipping, cementation ("sherardising"), electrodeposition from several types of bath, and by metal-spraying with several different types of pistol. The experiments show that differences in the process of application are of minor significance and that the effective life of zinc coatings is mainly determined by the coating weight (Fig. 20).

Sprayed metal coatings form an excellent basis for paint. Indeed in severely corrosive atmospheres, such as those of chemical works, effective protection cannot be obtained by direct painting on to steel and the provision of a metal coating beneath the paint is essential. In a recent paper, O. van Rossum[13] describes how heavy corrosion in the German chemical industry led to the adoption of a protective scheme consisting of a sprayed zinc coating about 4 mils thick followed by one or two coats of a synthetic paint. The cost of this method was roughly double that of painting alone, using four coats of paint but experience to date shows that the duration of protection achieved will be increased in a considerably greater ratio. Experience in Great Britain confirms this view and a practical example of the excellent protective value of a sprayed metal coating in a highly corrosive atmosphere will be given in section 5.2.

(iii) **Other coatings.** There are numerous coatings which, without having a wide application, are useful for certain special purposes. For example, under some very severe conditions of exposure, corrosion can be prevented by the use of wrapping tapes and greases containing inhibitors, which are used to encase the steel like a mummy. Extruded or sprayed plastic coatings, fitting the steel sections like a glove, are also beginning to be used in the same way.

Vitreous enamel has excellent corrosion resistance and is particularly suitable for the protection of rainwater pipes and fittings. Here the slightly higher original cost of the article is offset by the fact that no painting is needed either originally or subsequently. The use of vitreous enamel for some purposes is limited by its vulnerability to mechanical damage but where this factor is absent, it has an almost indefinite life when used as a coating for steel exposed to the atmosphere, immersed in water or buried in the soil.

Some remarks about protection by cement and concrete coatings, which are also of great value, will be made later in section 5.6.

Finally, tars and bitumens, which are extensively used for marine purposes, should be mentioned. There is no doubt of their value, providing they are put on sufficiently thickly and often. In some atmospheric exposure tests by the British Iron and Steel Research Association a coat of hot-dipped tar mixture applied to steel protected it for 2½ years outdoors at Sheffield, whereas a 4-coat painting scheme applied to a properly descaled surface did so for more than 10 years. On the other hand the tar coating was roughly only half as thick as the painting scheme and it might have given a better performance if it had been built up to a greater thickness, say by renewal at yearly intervals.

There is ample scope for further research on protective coatings of tars of bitumens. The protection yielded by tar can be increased by treating it with substances such as lime, tallow or resin, so as to neutralise corrosive acids, thicken the mixture and decrease the drying time. A mixture used by British Railways (Western Region) consists of 1 lb. each of slaked lime and tallow per gallon of tar. It is prepared by heating half of the tar with the tallow at 160°C. and dusting in the lime, stirring the mixture until the froth subsides. The remainder of the tar is then added and heating at about 170°C. is continued for half an hour. The mixture is applied by bringing it to the boil and keeping it at 100° C. until it has been brushed on; it should not be allowed to boil more than once. A dehydrated horizontal retort coal tar is specified. *(To be concluded)*

[13] O. van Rossum: "Economical Protection against Corrosion of Steelwork in the Chemical Industry." Chemische Industrie, 1952, 4 July, 463-4.

Quayside and Warehouse Flooring

Good Surfaces Essential for Efficient Cargo Handling

The importance of the quality of harbour flooring, as a vital contributing factor to more efficient cargo handling, is now becoming more widely recognised. In many instances the rapid loading and unloading of ships is indirectly impeded by the poor state of quayside and warehousing flooring, and uneven or dilapidated flooring surfaces increase considerably the difficulties of man-handling cargoes speedily and efficiently. In addition, rough, uneven cobble stones and cracked and badly worn granolithic floors have all too often been responsible for much needless breakage and wastage through excessive vibration caused to traffic. The smooth movement of forklift trucks and other cargo carrying vehicles must be ensured if a quicker turn-round of cargo ships is to be attained.

In recent years the overall mass of cargo passing through ports has multiplied considerably and, to meet the increased loads, the forklift truck and various other mechanical handling devices have come into use. Yet many ports are still using flooring not originally designed to carry the greatly increased loads of modern traffic.

There are two main types of flooring which tend to suffer from rapid deterioration of their wearing surfaces: uneven and badly laid floors, with surfaces incapable of withstanding heavy abrasive wear, and floors, laid on soil which tends to move or subside, whose general design does not allow for any subsoil movement that may occur.

Briefly, the most important practical advantage required by modern quayside and warehouse flooring would seem to be:—

(1) Considerable strength, particularly in the wearing surface. Those wearing surfaces provided by concrete, heavily impregnated with steel chippings, are very suitable.

(2) A flooring which can be easily and quickly laid and worked on immediately, thereby offering a considerable economy in time and labour.

(3) A flooring made up of individual units which can be lifted and moved when necessary. There is at least one product on the market which possesses the necessary characteristics, providing a floor of individual units simply laid on a bedding of compacted sand. This type of flooring is particularly suitable in places where the problem of subsoil movement presents itself. On poor subsoils, which are subject to subsidence subsoil movement will affect only isolated units and not the flooring as a whole.

If individual units, laid on a bedding of sand, start to sink or move, the remedy is quick and simple. All that is necessary is to lift the unit (or units) affected, relevel the sand underneath and replace the unit. This allows a considerable economy in time and costs of repair work.

By using this type of floor unit, Port and Harbour Authorities will undoubtedly be able to reduce the delay and wastage caused by the unsmooth movement of cargo carrying vehicles. An immediate increase of general efficiency and a long-range form of economy should result.

Jetty for Refinery at Kwinana.

According to reports received from Australia, work has commenced on the construction of the permanent jetty for the £A30,000,000 oil refinery which is being built at Kwinana, near Fremantle, for the Anglo-Iranian Oil Company, Ltd. The jetty will provide three berths capable of accommodating the world's largest tankers. One arm will extend about 1,000-ft. out from the shore at Cockburn Sound, and the sea arm will be 1,700-ft. long. In addition to the oil refinery, steel and cement works are to be established in the neighbourhood by other companies at a cost of more than £A60,000,000.

Floating Pneumatic Grain Elevators

New Plants for the Port of London

THE principal function of a floating pneumatic grain elevator is to prevent costly delays when the cargo of an ocean-going grain ship has to be distributed at a number of dispersed points in a dock area or at various smaller ports around the coast. In such cases, rather than move a large vessel from berth to berth or from port to port, it is far quicker and cheaper to tow a floating elevator to the ship at a convenient place and discharge the entire cargo into barges or small craft; these can subsequently be discharged by shore plants wherever required and whenever convenient; the ship itself being thus relieved of delays and dock dues and set free to go about its normal duties.

The *John Anderson* and the *Douglas Ritchie*, two identical plants completed and commissioned in 1951 and 1952 respectively, are of considerable interest in that they are the latest of a series of floating pneumatic grain elevators designed and built for the Port of London Authority by Simon Handling Engineers Ltd. at intervals over a period of some forty years. These two plants, each with a rated maximum capacity of 300 tons of grain per hour, are capable of discharging the largest grain vessels using the Port of London; in capacity they are amongst the biggest plants of their kind in Europe, and in design they are probably the most up-to-date at present in use anywhere.

Pontoons.

The pontoons were built to the requirements of Lloyds 100A classification by J. Samuel White & Co. Ltd. at Cowes, the moulded dimensions being 82-ft. 3-in. long by 36-ft. 6-in. beam with a depth of 13-ft. 6-in. They contain ballast tanks and pumps for maintaining the trim of the plant, storage tanks for 40 tons of diesel oil fuel, stores, workshop, and accommodation for the crew, including lockers, fresh water storage, wash basins, etc.

Power driven warping equipment is provided on deck for handling barges and hauling the plants alongside ships.

Engines and Vacuum Pumps.

The main engine, vacuum pumps and generator sets are installed at the lowest level in the pontoon in order to give the plant the maximum stability. Two generator sets, one of 70 k.w. and one of 35 k.w., are provided to supply direct current at 220 volts for lighting and for the operation of control gear and auxiliary machinery; both sets are driven by marine-type six-cylinder 4-stroke airless injection diesel engines running at 1,000 r.p.m. and direct coupled to the generators.

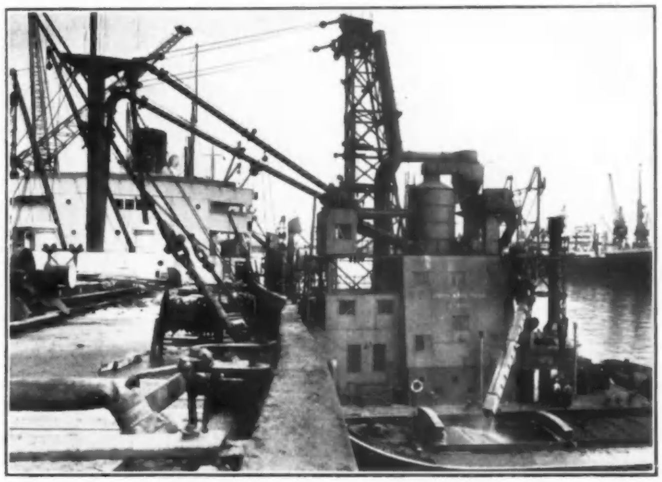
The main engine is a marine-type 6-cylinder Ruston diesel engine rated at 475 b.h.p. continuously or 530 b.h.p. for twelve hours; it is of the 4-stroke airless injection pressure-charged type and is arranged for cold starting by compressed air, two compressor sets being provided. The speed can be controlled over a range of 400 to 500 r.p.m., the latter being the normal running speed. The drive is taken through a Vulcan-Sinclair fluid clutch coupling to a single-reduction totally enclosed double helical gear unit by Turbine Gears Ltd., giving a speed reduction from 500 to 115 r.p.m.

The slow-speed shaft from the gear unit drives the twin vacuum pumps which provide suction for grain discharging. They are standard Type 20A Simon pumps of the vertical double-acting reciprocating type. The large-bore short-stroke cylinders are of cast iron and are surrounded by air jackets divided into suction and exhaust sections; the suction and exhaust valves are arranged in the top and bottom cylinder covers, each valve, with its spindle, seating, spring and cap, forming a complete removable unit which is held in position by dogs and screws. The cylinders are carried on heavy cast iron A-frames and bedplates, and the pistons are driven by crossheads and connecting rods from a common crankshaft carrying two separate flywheels. All moving parts are oil-lubricated except the pistons, which are dry-lubricated by a special graphite composition packed in blind holes on the outer faces of the piston rings; this method avoids any risk of excessive wear arising from oil becoming clogged with traces of fine dust in the air passing through the cylinders.

Grain Handling Equipment

Suction Piping.

Grain is withdrawn from the ship's hold through two independent suction pipelines, each of which is bifurcated at the intake end to allow two suction nozzles and flexible pipe runs to be attached; four nozzles can thus be operated simultaneously. The nozzles are coupled by quick-action flanges to lengths of flexible piping, the number of lengths used depending on the freeboard of the grain ship and the level of grain in the hold. The flexible piping is in turn coupled by quick-action flanges to the bifurcated ends of the two telescopic vertical intake pipes, each of which has a telescopic travel of 18-ft. The upper ends of the vertical telescopic pipes are attached by flexible piping and socket joints to the outer ends of the two intake pipe booms. The booms are supported from a braced steel tower.

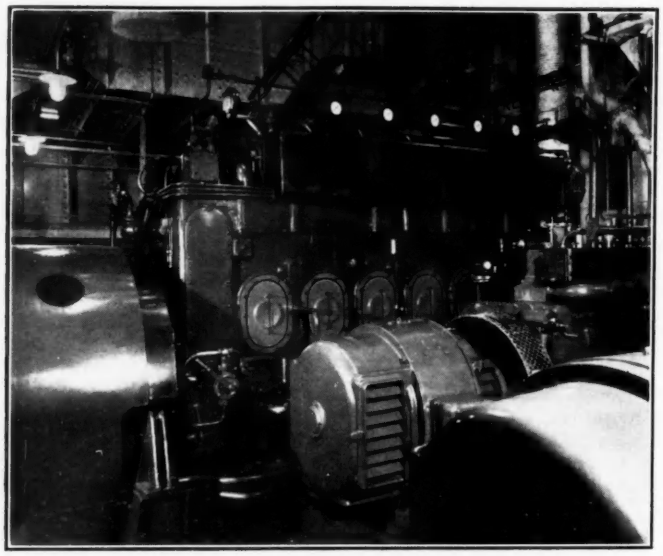


View of Pneumatic Grain Elevator working side-on to a ship.

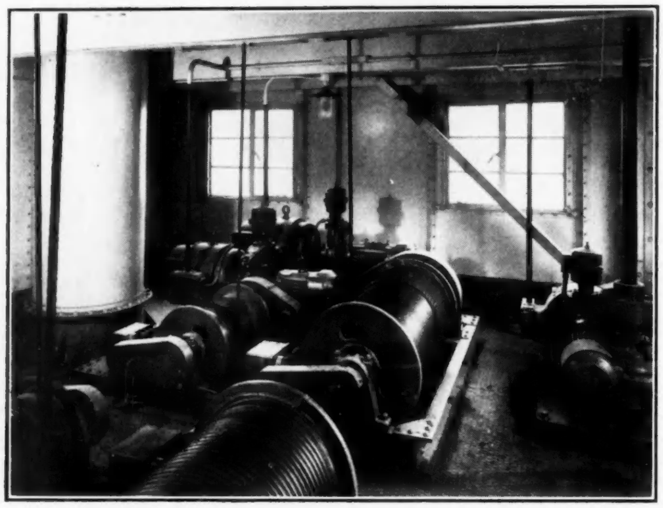
The position of the nozzles in the ship's hold is controlled in four independent ways. The pipe booms carrying the vertical piping and nozzles can be luffed up and down; they can also be slewed from side to side; the telescopic pipes allow the nozzles to follow the grain level down through a range of 18-ft. without moving the booms or adding extra lengths of flexible piping; finally the flexible piping allows the nozzles to be manhandled over a wide area in the hold without moving either the booms or the telescopic pipes. All movements of the booms and telescopic pipes are made by electric motors and are controlled by limit switches; the booms are luffed and the pipes telescoped by winches and wire cables running over guide-pulleys, slewing of the booms being accomplished by vertical shafts and reduction gears. All power-operated movements are separately controlled so that they can be made either in sequence or simultaneously, and each pipe boom can be luffed and slewed independently of the other.

Pipe movements are operated from a winch-room and are controlled from a cabin with windows on all four sides, through which the winchman can see the pipes and booms in all positions. The cabin is placed high enough to give the winchman a view of the ship's deck so that he can observe visual signals for pipe movements given by a man at the hatches. Means are provided for communication between the winchman and the engine-room of the floating elevator by telephone, signal light and hooter.

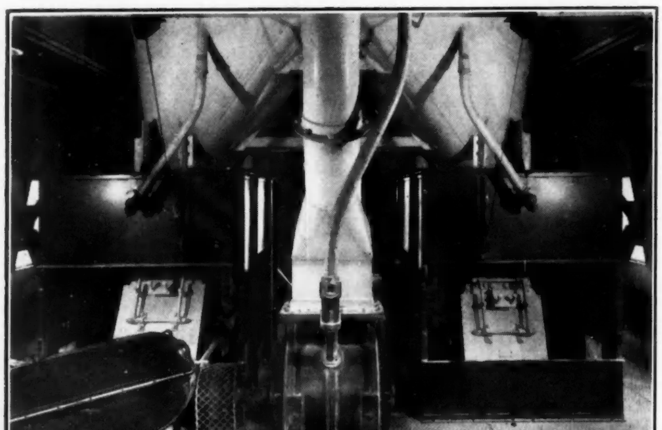
Floating Pneumatic Grain Elevators—continued



The Main Diesel Engine.



The Winch Room.



The Tipper Seals.

When the floating elevator is not is use the pipe booms are stowed inboard and stowed in cradles alongside the superstructure. The suction nozzles and lengths of flexible piping are stowed in racks on the pontoon deck, from which they are hauled up when required by jigger winches attached to the pipe booms.

Dust Extraction.

The air and grain drawn through the suction piping are discharged into a large vertical cylindrical receiver by two pipes leading from the pipe booms and entering the receiver near the hoppered bottom. Inside the receiver the conveying air expands, thus losing velocity and allowing the grain to fall out of suspension. From this point onwards the air and grain follow separate paths, and it will be convenient to deal first with the air.

The air, after being separated from the grain in the receiver, remains laden with grain dust, which must be extracted as completely as possible before the air passes on into the vacuum pump cylinders and is discharged to atmosphere; this is essential not only to prevent abrasion in the pump cylinders but also to avoid creating a nuisance. The main dust extraction takes place in two cyclone separators in series, the first cyclone being installed inside the receiver and the second outside it. As a final precaution, just before entering the pump cylinders the air passes through an air receiver fitted with a grid having slot perforations of 1.5 x 15 millimetres. This receiver not only serves as an expansion chamber for the pumps but also collects any pieces of string, grass or other foreign matter which may not have been deposited with the grain in the main receiver; any accumulation of such material can be removed periodically. A high overall dust separation efficiency is achieved, and the air finally discharged to atmosphere is substantially dust-free.

The dust extracted from the air forms part of the ship's cargo, and as grain cargoes are weighed both on loading and on discharge it is normal commercial practice to feed the separated dust back into the main grain stream in order to avoid any discrepancy between the initial and final cargo weights. The dust removed by the cyclone inside the receiver and by the external cyclone is therefore returned through separate shoots and rotary air seals into reception hoppers below the receiver outlets for weighment with the grain.

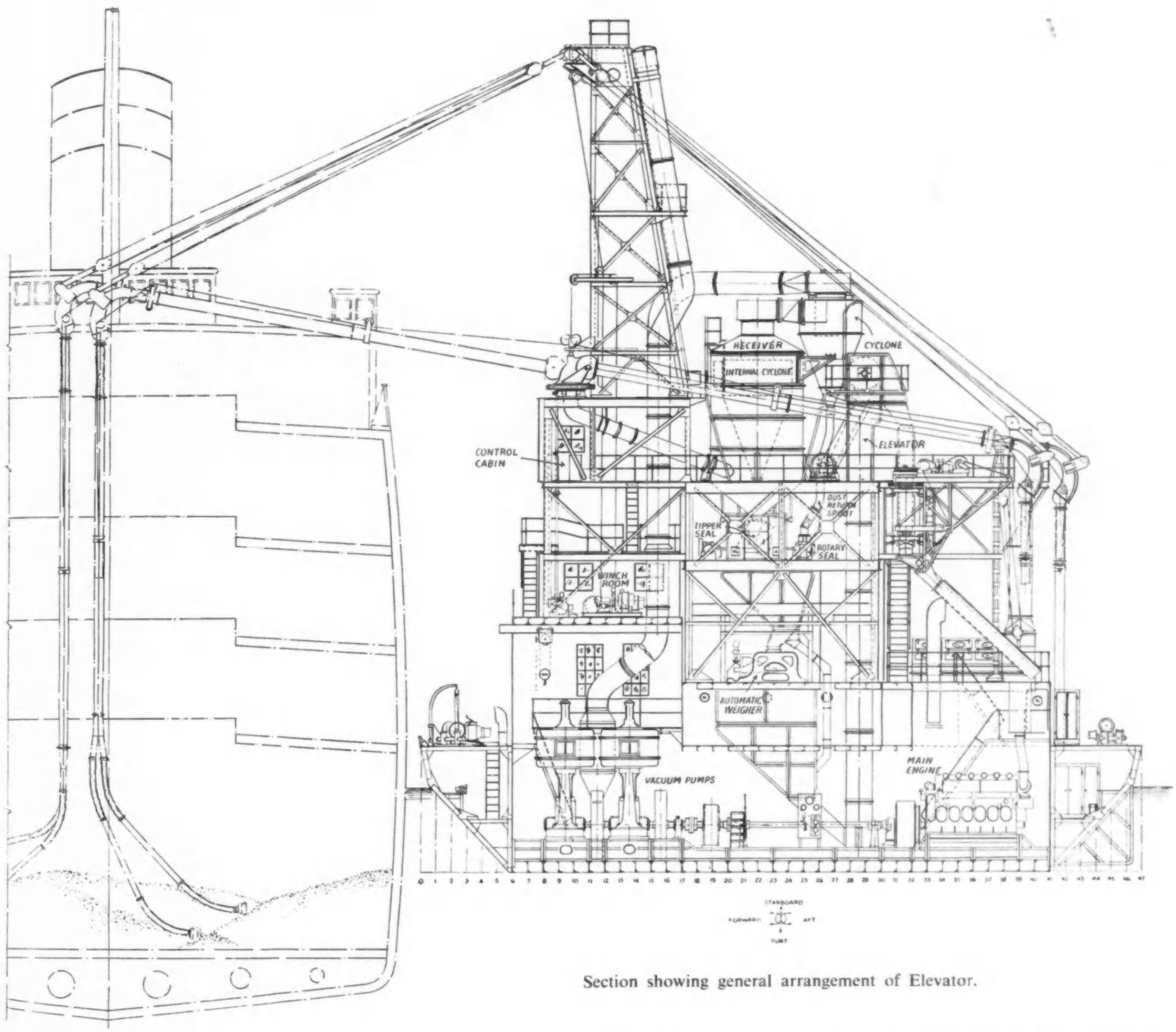
Tipper Seals.

It will be realised that the receiver is under constant suction, and that means must therefore be adopted to discharge the grain from it without breaking the vacuum. This is accomplished by means of two standard Simon tipper seals or tumbling boxes, which are fitted below the twin outlet hoppers of the receiver. The tipper seal consists essentially of a steel-plate receiving box divided into two separate compartments by a vertical central partition; each compartment has at the bottom a free-swinging outlet flap or door, which is hinged at the upper edge. The complete tipper seal is rocked from side to side on a pivot just below the bottom of the central partition, each oscillation taking about three seconds; the top of the seal and the bottom of the receiver outlet are shaped as arcs of a circle, thus forming a sliding joint which is kept air-tight by leather sealing strips.

When the tipper is at one extreme of its oscillation the inlet of one of its two compartments is brought under the receiver outlet and is rapidly filled with grain, the outlet door of the compartment being meanwhile held shut by atmospheric pressure. As the tipper rocks to the opposite extreme, the inlet of the filled compartment comes into communication with the atmosphere, thus breaking the vacuum in the compartment and allowing the grain to flow through the outlet door; meanwhile the second compartment is under the receiver outlet and is being filled with grain, which is similarly discharged at the next oscillation

Each tipper is driven by a separate electric motor through reduction gearing, from which are also taken the drives to the rotary air seals through which the separated dust is returned to the grain. The tippers themselves are oscillated by cranks and connecting rods, the connecting rods being spring-loaded so that any obstructions such as pieces of rope, wood or metal picked up with the grain will neither damage the tipper nor interrupt the working of the plant.

Floating Pneumatic Grain Elevators—continued



Section showing general arrangement of Elevator.

Grain Weighers.

The two streams of grain discharged from the tippers are received in two compensating hoppers and are weighed separately by a pair of automatic weighers. Each weigher is carried in a swinging frame and discharges two tons of grain per weighment, each weighment being automatically recorded by a counter. The weighers are of the standard Simon "Reform" automatic type, requiring no source of power for their operation apart from the weight of the grain; when the weigh bucket has received its full two-ton weighment the motion of the scale beam automatically closes the feed gate and opens the bucket door, releasing the grain into a second compensating hopper, after which the bucket door is automatically closed and locked, the feed gate being re-opened by the reverse motion of the scale beam. When the floating elevator is working at full capacity the complete cycle of operations occupies approximately 45 seconds.

A residue-weighing mechanism of the orthodox steelyard and sliding counterpoise type is provided for weighing odd quantities of grain left over at the end of the cargo. A manually-operated ticket-printing device is incorporated for recording the residue weighments.

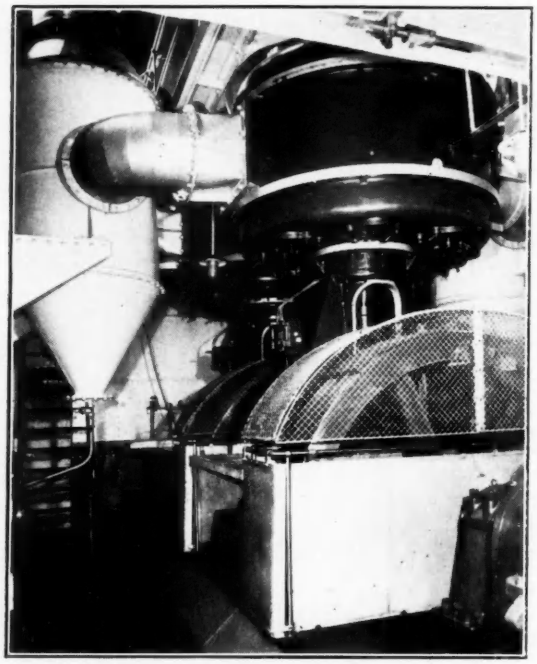
To cater for the comparatively rare occasions when there is no necessity to weigh the grain, by-pass spouts are provided by means of which the grain can be sent straight from the upper to the lower compensating hoppers without passing through the weighers.

Grain Discharge to Barges.

The two weighed and recorded streams of grain are discharged, still as separate streams, from the compensating hoppers below the weighers to two bucket elevators of orthodox type, which raise the grain to a height from which it can be delivered by gravity to barges or small craft alongside. The spouts from the elevator heads are brought to a cross-over junction fitted with a throw-over valve, by means of which the two streams can either be delivered separately on both sides of the pontoon or can be combined and delivered together on one side or the other.

The loading-out shoots are telescopic and are carried from braced steel cantilevers which enable them to be luffed and slewed over barges or small craft and brought inboard for stowage when the plant is not working. A unique feature of the *John Anderson* and the *Douglas Ritchie* is that the luffing, slewing and telescoping movements of the loading-out shoots are all power-operated, a refinement which was provided at the special request of the Port of London Authority and is not to be found in any other floating pneumatic grain elevator at present in existence; the value of this

Floating Pneumatic Grain Elevators—continued



The Vacuum Pumps.

feature in economy of time and labour has been amply shown in practical use.

Performance.

The *John Anderson* and the *Douglas Ritchie* are designed to work either side-on or end-on to the grain ship and to give the same performance in either position. As stated earlier, each plant has a rated maximum capacity of 300 tons of grain per hour; allowing for some loss of capacity when trimming the last of the grain cargo up to the nozzles at the bottom of a practically empty hatch, each plant can achieve an average discharging rate varying from 225 to 250 tons per hour, which means that the two plants working together can unload a 10,000-ton cargo in less than twenty-four hours' continuous working.

The high ratio between the average and the maximum discharging capacities will be noted. This is an advantage common to all Simon pneumatic discharging plants; it arises mainly from the fact that the suction nozzles of a pneumatic plant (unlike the boot of a " marine leg " of the bucket elevator type) can maintain full intake capacity in a small depth of grain and can be readily manœuvred right up to the sides of the hold and into awkward corners to extract the last of the cargo. For the same reasons a pneumatic plant requires the minimum of physical labour in trimming the grain, and consequently the minimum of total manpower for plant operation. A further advantage of no small importance is that, since the grain is drawn into the nozzles under suction, the few men in the hold are not choked by the clouds of intensely disagreeable grain dust raised by the buckets of a marine leg; it would be interesting to speculate on how much injury to health and how many man-hours of extreme physical discomfort are nowadays saved by the wide use of pneumatic grain discharging plants.

It will also have been noted that all movements of intake pipes, loading-out shoots and so forth are power-operated; in fact practically no normal operation is performed manually except that of coupling up the suction intake nozzles and flexible pipes. Any extra capital cost incurred in this way has been found to be more than amply repaid in economy of year-to-year operation. This was strikingly demonstrated some little time ago, when one of the plants described in this article was working alongside a plant of another type with hand-operated pipe booms and shoots; the latter took an hour and a half to get to work on the grain cargo, whereas the Simon plant went into action in less than ten minutes.

Hydraulic Research

Fifth Congress of International Association

By LORENZ G. STRAUB, President.

The Fifth Congress of the International Association for Hydraulic Research which is to be held in Minneapolis on the campus of the University of Minnesota is the first meeting of the Association on the American continent. It will be held jointly with the Hydraulics Division of the American Society of Civil Engineers, the latter holding its second divisional meeting; the Section of Hydrology of the American Geophysical Union will also hold a meeting on the University campus immediately preceding the Hydraulics Congress.

The opening session of the Congress will be in the auditorium of the Museum of Natural History the morning of September 1 next. Preparations for the Convention have been undertaken by local committees established by the North-Western Section of the American Society of Civil Engineers with headquarters at the St. Anthony Falls Hydraulic Laboratory of the University of Minnesota. The technical proceedings for the meetings, including 49 hydraulic papers, are currently being published and will be issued immediately preceding the Congress. This comprehensive work involves the collaboration of 75 authors who include leading experts in the field of hydraulic research from some 20 countries. It can be purchased through the Secretary of the Convention Committee, price $6.00 per copy.

The theme of the Congress is encompassed by four symposiums toward which all technical papers are directed. Geophysical aspects of hydraulics make up the theme as follows: (a) Basic Relationships of Sediment Transportation by Flowing Water, (b) Density Currents, (c) Air Entrainment by Flowing Water, and (d) Waves, Beach Erosions, and Hydromechanics of Shore Structures.

The Hydraulics Congress will be in session from September 1st to 4th inclusive. The regional hydrology meeting of the American Geophysical Union will be held on August 31st. Housing for the large attendance is being arranged on the campus of the University of Minnesota as well as in Minneapolis hotels. Social evenings are planned, while the evening of September 3rd is being arranged as an open technical forum.

Speakers and participants from outside of the Americas will include Mr. Pierre Danel, Director, Neyrpic Hydraulic Laboratory, Grenoble, France; Dr. Wolmar Fellenius, Professor Emeritus of the Technical University, Stockholm, Sweden; Dr.-Ing. Milovan Goljevscek, Professor at the Technical University, Ljubljana, Yugoslavia; Professor J. Th. Thijsse, Director, National Hydraulic Laboratory, Delft, Netherlands; Sir Claude Inglis, Director of the Department of Scientific and Industrial Research, Hydraulics Research Organisation, London, England; Mr. A. Nizery, Chief Engineer, Hydraulic Laboratory Director, Electricité de France, Paris, France; Dr. L. Escande, Professor and Director, Hydraulic Laboratory, Toulouse, France; Professor G. Evangelisti, University of Bologna, Italy; Professor L. J. Tison, General Secretary, International Association of Hydrology, Gentbrugge, Belgium; Professor Masashi Hom-ma, Tokyo University, Tokyo, Japan; Mr. D. Doddiah, Assistant Director, Hydraulic Research Station, Mysore, India; and other well known hydraulic engineers. Many American and Canadian scientists and engineers will also participate.

New York Harbour Channels.

According to reports in the American Press, the U.S. Army Corps of Engineers is shortly to commence work on deepening two congested channels in New York harbour. When completed, the improvements will make Gowanus Creek Channel, and part of the middle reach of the New York—New Jersey Channel available to deep-draft shipping, that at present has to wait, at considerable cost, on wind, tide and traffic to reach berths in those areas. The deepening has long been sought by shipping companies, waterfront terminal operators and pilots. The easier of the two projects is the deepening of Gowanus Creek to 30-ft. at a cost of $349,000 as the soft sea bed can be dredged in three or four months. The other project involves work on nearly a mile of channel from a point off 28th Street to the Hamilton Avenue Bridge and half of the 2,000-ft. long Henry Street Basin. The depth of all but the inland five blocks of the channel is 26-ft. Both schemes will cost a total of $1,140,000 during the fiscal year.

Sea Pollution by Oil

Report of Ministry of Transport Committee

The report of the Committee appointed by the Ministry of Transport last October has just been published.* The evil with which the report deals arises from the false but widespread belief that any one section of the community is entitled, for the sake of operating convenience or commercial interest, to cause widespread distress—" to waste the world around it and destroy the amenities, even livelihood, of its neighbours," in the words of a leading article in "The Times." The forthright recommendations contained in this report have attracted interest and attention, and, with the public support which is likely to follow this, there is reason to hope that most of its recommendations, quoted in summarised form below, will receive early attention by the British Government.

The committee, under its chairman P. Faulkner Esq., C.B., represents British shipping and Dock and Harbour interests, and has had the benefit of the knowledge and experience of many experts, as is evident from study of the report of nearly 20,000 words.

The Committee considered that the evidence about the extent of oil pollution was already so overwhelming that there was no point in taking oral evidence of its extent and effects. Consideration has, however, been given to a large number of constructive suggestions upon the methods of prevention, submitted by various bodies. Although the Committee's terms of reference were restricted to a study of measures to prevent pollution of the waters around Great Britain, regard to the international aspect of the problem has not been neglected.

Among the places in Great Britain which have been worst affected are the vicinities of Heysham, Cardigan Bay, Cornwall, the eastern part of the Isle of Wight, the south-east coast of England and the Tees area. Pollution is not continuous at all these points; indeed it is often spasmodic and associated with gales from particular directions. The ill-effects of oil pollution are categorised as

(a) The spoiling of beaches and the amenities of coastal resorts.
(b) The destruction and injury of sea birds.
(c) The fouling of boats, fishing gear, piers, quays, etc.
(d) Damage to fish, shellfish and larvae.
(e) Risk of fire in harbours and other enclosed waters.

Of these, (d) and (e) appear to be relatively less serious, although there have been occasional cases of hardship to shellfish and inshore fishing interests.

The considerable increase both in oil-burning vessels and in the international carriage of crude oil (rather than refined and more volatile hydrocarbons, such as petrol) in the post-war years are considered to be causes of the recent aggravation of this trouble, and data is given upon the movement of oil tankers and European oil imports.

The report continues with an outline of previous investigations into the extent of drift of oil discharged at sea, and with some description of experiments initiated by British oil companies into this problem in 1952. Charts are published, used for the prediction of oil drift at various times of the year. An important factor is the extent to which oil discharged can be regarded as persistent, and the following distinction is made:

(a) Persistent Oils. The following should be regarded as persistent:
(i) All hydrocarbon oils other than those distillates of which more than 50 per cent. by volume distils at a temperature not exceeding 340°C. when tested by Method I.P. 123/49 ("Standard Methods for Testing Petroleum and its Products"). In this category are crude oil, residual fuel oils and lubricating oils.
(ii) Tar oils, creosote and similar substances.

(b) Non-persistent oils. The following should be regarded as non-persistent:
(i) Distilled hydrocarbon oils which come within the exception referred to in (a) (i) above. In this category are motor spirit, kerosene and gas oil.
(ii) Animal and vegetable oils.

Sources of Discharge from Ships

The various ways in which oil or oil emulsions may become discharged at sea are set forth as follows:

(a) Sources of discharge peculiar to tankers:
(i) Tank washings and sludge and oil-contaminated ballast water from cargo tanks.
(ii) Leakage from cargo tanks or pump rooms and discharge of oil from cofferdams.

(b) Sources of discharge peculiar to dry-cargo, passenger and miscellaneous vessels.
(i) Oil-contaminated ballast water from bunker fuel tanks which have previously contained oil.
(ii) Tank washings from deep tanks used for the carriage of oil as cargo, usually animal and vegetable oils.

(c) Miscellaneous sources of discharge from ships:
(i) Oil-contaminated water from machinery space bilges.
(ii) Tank washings and sludge from bunker fuel tanks.
(iii) Oily residue from settling tanks; oil fuel pumping, heating and filtering units; centrifugal separators; lubricating oil circulating tanks, etc.
(iv) Spillages when unloading or loading oil as cargo, or when bunkering, or when transferring oil from one tank to another within the ship.
(v) Leakage through structural defects.
(vi) Accidental discharges through stranding, collision, etc.
(vii) The discharge of oil at sea for salvage or life-saving purposes

Furthermore there is no doubt that some oil reaches the sea from sources on land, but there is no evidence that a substantial amount of pollution is so caused. However, industrial establishments and refineries should, it is advised, be encouraged to continue to take care in avoiding the discharge of obnoxious matter into sewers, rivers and harbours, as is required under the existing Oil in Navigable Waters Act, 1922, and under various bye-laws.

Oil in Docks and Harbours

From time to time some docks and other enclosed waters become polluted by floating oil. If, despite all the measures recommended, pollution of this kind occurs—and there may well be cases where despite all precautions oil escapes or is accidentally discharged—the responsible authorities should take all possible steps to remove the oil so that it neither continues to pollute those waters, nor finds its way out to pollute adjacent waters. Similarly, dock or harbour authorities or inland navigation authorities should do everything possible to remove concentrations of floating oil from the tidal waters under their jurisdiction before the pollution becomes more widespread.

Immediate Action and Long Term Policy.

Protection of the waters around British coasts obviously cannot be assured by prohibitions which, outside British territorial waters, can apply only to United Kingdom registered ships. There is a very substantial tonnage of foreign shipping passing near our shores, and proceeding either to United Kingdom ports or to those on the Continent, and as jurisdiction over these ships on the high seas can be exercised only by the country of their flag, it is clear that the co-operation of other maritime countries is necessary if the problem is to be solved. Similarly, the co-operation of the Government of the United Kingdom is necessary if the problem of pollution of the coasts of other countries is to be dealt with effectively.

A system of prohibited zones would not in itself provide a satisfactory solution of the problem of coastal pollution; nor would it entirely prevent the oiling of sea birds and the consequent destruction and suffering caused to them. The conclusion therefore is that as soon as possible H.M. Government should seek the agreement of the other maritime countries to the fixing of a date after which discharge into the sea of persistent oils by ships of any country would be prohibited. An exception could safely be made for discharges from bilges, provided precautions were taken to avoid the discharge of any fuel oil. The date would have to be sufficiently far ahead to give time for the necessary arrangements to be made both in ships and on shore.

*H.M.S.O. "Prevention of Pollution of the Sea by Oil." Price 2s. net.

Sea Pollution by Oil—continued

While it is hoped that international discussions will bear fruit, it seems inevitable that they will take a long time; the recommendation is made that, as a first step and as a token of British intentions and of our appreciation of our obligations as a sea-going nation, certain prohibitions should be applied to ships registered in the United Kingdom. The chart reproduced here prepared on the basis of the advice of the National Institute of Oceanography shows the zone considered to be appropriate as a prohibited area. Full observance of the prohibition will not be possible unless arrangements are made for ships to hold on board such oily residues as cannot be consumed and unless facilities for the disposal of these residues at British and foreign ports are provided.

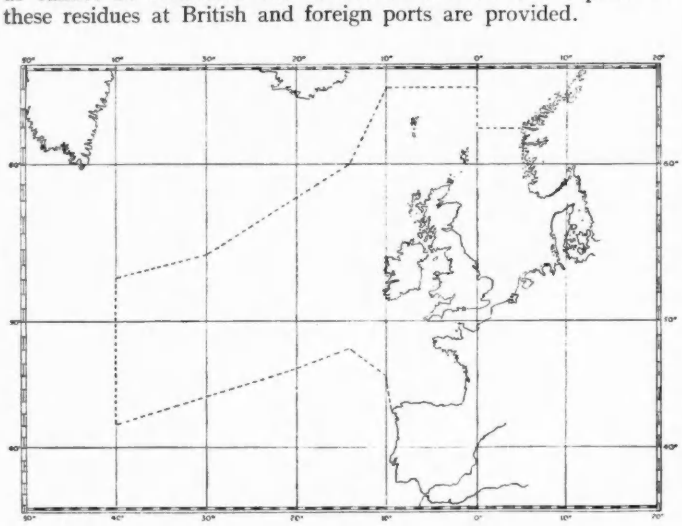


Chart D, showing proposed Prohibited Zone.

Disposal of Oil and Oily Residues

Broadly, there are only two ways of keeping oil out of the sea; namely, discharge of all oily residues ashore, or separation and consumption of the recovered oil in the ship. Each presents its own special problems. With a few exceptions waste oil reception facilities are inadequate, or non-existent, in United Kingdom ports although, with the possible exception of the United States of America, this country is probably better equipped than most other countries in this respect. Where facilities do exist they normally take one or more of the following forms.

(a) Special berths equipped for the reception and disposal of oily wastes. The normal equipment comprises pipe-lines at individual docks connected to storage tanks, separating plant or refineries. The berths are sometimes equipped for tank cleaning as well. Berths equipped in this way are normally available only at ports used by tankers.

(b) Tank cleaning vessels, usually equipped with separating plant, which clean tankers' cargo tanks and the fuel tanks of other vessels in port, or in the waters adjacent thereto.

(c) Barges which go alongside vessels and receive and separate oily wastes.

(d) Barges, not equipped with separating plant, which transport oily wastes ashore.

(e) Separating apparatus or storage tanks in repair yards and dry docks.

(f) Collection and disposal services, usually provided by commercial oil-recovery firms, for waste oil which has been collected on board ship in drums or tanks.

Summary of Recommendations

After analysis of the problem and a detailed study and recommendations applicable to deep-sea tankers, coastal tankers and dry-cargo ships, the report concludes with a summary of its recommendations, which are reproduced below, and which it is hoped will be given urgent attention.

Definition of "Oil" and Persistence of some Oils.

(1) We have defined oils which are persistent; they include crude oil, residual fuel oil and lubricating oil. It is the persistent oils that cause most of the pollution around our coasts, and we recommend that new restrictions, to apply outside the territorial waters of the United Kingdom, should be placed on their discharge into the sea.

(2) The existing prohibition on the discharge of any oil, whether persistent or non-persistent, into the sea within our territorial waters and harbours should continue and should apply to tar oils, creosote and similar substances.

International Action.

(3) As jurisdiction over ships on the high seas can be exercised only by the country of their flag, total prohibition of the discharge of persistent oils into the sea outside territorial waters can be brought about only by international agreement. We recommend that as soon as possible H.M. Government should seek the agreement of the other maritime countries to the fixing of a date after which discharge into the sea of persistent oils by ships of any country would be prohibited. (An exception could safely be made for discharges from bilges, provided precautions were taken to avoid the discharge of any fuel oil.) The date would have to be sufficiently far ahead to give time for the necessary arrangements to be made, both in ships and on shore.

Prohibited Zone.

(4) The prohibition of the discharge of persistent oils within a prescribed zone is no more than a palliative, since there can be no guarantee that they will not eventually drift ashore and cause pollution. Nevertheless, as an interim measure the discharge of persistent oils by United Kingdom registered ships should be prohibited within a wide zone around the United Kingdom. The zone which, in the light of the advice of the National Institute of Oceanography, we recommend should be prescribed is shown in Chart D (reproduced).

(5) The prescription of the prohibited zone referred to in recommendation (4) should not affect the continued observance of the voluntary agreement whereby oil is not discharged by ships of the participating countries within 50 miles of any coast.

Deep-Sea Tankers.

(6) The main problem in deep-sea tankers is the disposal of tank washings and oil-contaminated ballast water from their cargo tanks, but these vessels can, without the use of separators, effect separation of most of the water by settling in a slop-tank. The oil-free water can be discharged overboard and the residue stored on board and discharged ashore, if suitable reception facilities are available at the port of arrival.

Until such time as the international agreement referred to in recommendation (3) takes effect, deep-sea tankers registered in the United Kingdom should, except in the case of discharges from machinery-space bilges (recommendation 11), comply with the following requirements:—

(a) Deep-sea tankers proceeding from United Kingdom or near-Continental ports to foreign ports (other than near-Continental ports) for loading, should not discharge any oily tank washings, oil-contaminated ballast water or other oily residues of the persistent types into the sea, unless facilities for the reception of oily residues are not available at the loading terminal. If no such reception facilities are available, the oily residues should not be discharged into the sea within the proposed prohibited zone shown in Chart D.

(b) Deep-sea tankers proceeding to a United Kingdom or near-Continental port for loading or repair should discharge any oily tank washings, oil-contaminated ballast water or other oily residues of the persistent types into reception facilities at the port of arrival. If no such reception facilities are available they should, as a purely temporary measure, be permitted to discharge those oily residues into the sea, but not nearer than 100 miles from the United Kingdom.

(7) Companies operating in the United Kingdom which charter foreign tankers, should endeavour to arrange that such tankers observe the same restrictions as those recommended for United Kingdom registered tankers.

Sea Pollution by Oil—continued

Coastal Tankers.

(8) Subject to recommendation (11) in regard to machinery-space bilges, coastal tankers, i.e. all tankers of less than 2,500 tons gross, should be prohibited from discharging into the sea any oily residues of the persistent types. As a temporary measure, however, we recommend that the discharge of oil-contaminated ballast water outside territorial waters should be permitted if reception facilities are not available at the port of arrival. Such discharges should, however, be made as far outside territorial waters as possible.

Dry-Cargo Ships (Including all Ships Other Than Tankers).

(9) The main problem is the disposal of oil-contaminated water from tanks which have previously contained oil fuel. Our recommendations are as follows:—

(a) All new dry-cargo and other ships on the United Kingdom register which use tanks alternately for oil fuel and water ballast, should be fitted with efficient separators of adequate capacity to ensure that as much of the ballast water from tanks which have previously been used for oil fuel as cannot without danger of pollution be discharged direct into the sea or harbour may be passed through the separator and discharged free from contaminating oil.

(b) As soon as possible, and by a date to be fixed by the Minister of Transport in consultation with the shipowners. all such existing ships should be similarly equipped, unless in any particular case the fitting of a separator is not reasonably practicable.

(c) Old ships nearing the end of their useful lives should be examined individually and provision made to exempt them from the requirement where the fitting of a separator would not be justified.

(d) Provision should be made to exempt ships under 3,000 tons gross which use gas oil as fuel if the Minister is satisfied that, having regard to the size, shape and position of the dual-purpose tanks, other suitable arrangements have been or will be made to render the fitting of separators unnecessary.

(e) Subject to recommendation (11) in regard to machinery-space bilges, dry-cargo and other ships on the United Kingdom register should not discharge any persistent oily residues within the proposed prohibited zone shown in Chart D unless such discharge would be permitted under recommendation (f).

(f) Until the date referred to in recommendation (b), ships that are not fitted with separators should be permitted to discharge oil-contaminated ballast water into the sea outside the territorial waters of the United Kingdom. In the case of any ship where the fitting of a separator is not reasonably practicable this should also be permitted. Such discharges should, however, be made as far from territorial waters as possible. Where adequate port facilities are available they should, of course, be used.

Reduction of the Quantities of Washing or Ballast Water in Tanks which have contained Oil.

(10) A large proportion of the washing or ballast water in tanks which have previously contained oil (either in tankers or other ships) can as a rule be discharged into the sea without danger of pollution. In this way the quantities of oily residue which require to be put through a separator and/or discharged ashore can be reduced to reasonable proportions and we recommend that the Oil in Navigable Waters Act, 1922, should be amended to enable clean water from tanks which have contained oil to be discharged in territorial waters and harbours.

Pumping of Bilges.

(11) Provided satisfactory arrangements, such as the provision of a special oil fuel bilge, are made to catch any leakage of fuel oil, so that it is consumed on board or stored for disposal ashore, we recommend that the pumping of machinery-space bilges should be allowed outside territorial waters. (The amounts of lubricating oil that find their way into bilges are small and can be ignored in relation to discharges outside territorial waters.)

Disposal of Oily Residues from Miscellaneous Sources in Ships.

(12) Oily washings from bunker fuel tanks or the residue remaining after they have been passed through a separator should be discharged into port reception facilities. The quantities of oily waste and sludge from settling tanks and filters, centrifugal separators, lubricating oil circulating tanks, etc., are as a rule comparatively small, and they should be stored within the ship and discharged ashore. Substantial quantities of sludge and oil are sometimes discharged into the sea from self-cleaning centrifugal separators used for cleaning heavy fuel oil for diesel engines; such discharges should cease. Until the difficulties of storing these amounts on board have been overcome, discharge into the sea should be permitted, but only outside the proposed prohibited zone.

Application of Recommendations to Crown Vessels.

(13) Our recommendations for merchant ships should be applied to H.M. ships, and to other vessels owned by the Admiralty, by means of Admiralty instructions. Vessels owned by other Government Departments should be made subject to the same statutory requirements as merchant ships.

Port Facilities.

(14) In the United Kingdom, facilities for the reception of oily residues from tankers are generally adequate at oil-refinery terminals but not at all other loading ports. They are not adequate at all foreign loading ports. The oil companies should provide adequate reception facilities at all loading terminals, both in the United Kingdom and abroad, as soon as possible. (We have been informed that the main oil companies operating in the United Kingdom will be prepared to co-operate in this way where the loading terminals are under their direct control, and they have undertaken to use their best endeavours with the companies with which they are associated to secure the provision of facilities at other loading terminals abroad.)

(15) Where reception facilities are not adequate at repair ports in the United Kingdom used by tankers, the repair firms should as soon as possible provide reception facilities adequate for such tankers as they undertake to repair.

(16) For oily residues from dry-cargo ships (including all ships other than tankers) the dock and harbour authorities, in collaboration, if necessary, with commercial oil-recovery firms, should provide, or secure the provision of adequate reception facilities. The Minister of Transport should seek statutory powers to enable him to require a dock or harbour authority to provide, or secure the provision of, the necessary facilities if, after the lapse of a reasonable time, he is satisfied that adequate facilities have not been provided at any particular port. The primary responsibility for the provision of reception facilities at repair yards for oily residue from these ships should rest on the ship repairers.

(17) Although the primary responsibility for providing reception facilities at all oil-loading terminals and repair ports should rest with the oil companies and the ship-repairers respectively, we recommend that dock and harbour authorities should have power to provide, or to co-ordinate the provision of, comprehensive reception facilities, in agreement with ship repairers and oil companies, for both dry-cargo ships and tankers using their ports and to make reasonable charges for such facilities.

Code of Conduct.

(18) The Minister of Transport, in consultation with the shipowners, the seafarers' associations and the oil companies, should arrange for the preparation and publication of a manual setting out a code of conduct for the avoidance of oil pollution. Consideration should be given to the inclusion of questions on measures for the prevention of oil pollution in examinations for Masters', Mates' and Engineers Certificates.

Chemical Treatment.

(19) The desirability of putting in hand a programme of research to determine the possibilities of chemical treatment as a means of preventing oil pollution should be considered.

Wrecks.

(20) The Minister or Transport should consider, in consultation with other interests concerned, whether the oil can be removed from wrecks containing substantial quantities of oil of a persistent character.

(continued at foot of following page)

Lightweight Concrete

Developments in the United States

Lightweight concrete is not, of course, a new building material, but during recent years its production, properties, economic aspects and use in its several forms have received increasing attention.

The term "lightweight concrete" is essentially relative and in its widest interpretation applies to all concretes in which some attempt has been made for the express purpose of reducing their density to a lower value than that of normal concrete made with gravel or crushed stone aggregate.

The method by which the voids are produced is often taken as a convenient primary subdivision of lightweight concrete into three main types. These are "no-fines" concrete prepared with a single-sized aggregate; concrete made with aggregates of low density; and "aerated" or "cellular" concrete produced by the formation of pores or bubbles of air or gas in the cementitious matrix.

The first named type originating in Holland, is now widely used all over the world for domestic building purposes and its properties are well understood. Aerated concrete also has achieved considerable progress in Europe but not to any great extent in America, although air-entraining cement has been much developed there. It must be pointed out however that air-entrained concrete should not, strictly speaking, be regarded as lightweight, since the inclusion of air is not for reducing weight but for improving workability and durability.

While low density aggregate concretes have been developed in certain European countries, American experience of such concrete is in various ways more extensive than British experience, particularly in regard to the scale of production, the range of aggregates employed and the use of the product in building.

For the purpose therefore of obtaining first-hand information on American practice a visit to the United States was arranged by the Building Research Board of the Department of Scientific and Industrial Research, under the aegis of the Economic Co-operation Administration who bore the costs.

The National Building Studies, Special Report No. 13, entitled **Lightweight Concrete in America,** is the outcome of the visit made by T. Whitaker, M.Sc., A.M.I.C.E. who is the author of the Report. During his extensive tour in 1950, he visited Government and University authorities and research organisations, trade associations and private firms and individuals.

In presenting the information obtained, the production and properties of the lightweight aggregates in general use are dealt with in a lengthy chapter, commencing with naturally occurring aggregate materials then by-product aggregates and finally manufactured and very lightweight aggregates. The processes connected with the production of expanded slag in the United States are described together with the latest American research on the bloating of clays. Particular interest is being shown in America at the present time in methods of producing lightweight aggregates by sintering and the data obtained from several research laboratories is given, together with descriptions of plants for the commercial production of aggregates, based on the work of the development laboratories.

Special attention is given in the Report to plants making concrete products and also to concrete blocks in use, and it seems that the industry has been built up to its present level in America largely by the outputs achieved by modern block machines. Moreover a further reason for the popularity of the lightweight concrete block in America is an economic one, for no matter what technical advantages they possess they produce a cheap structure.

There are chapters devoted to precast roof units, in situ construction and very lightweight aggregates and plasters, and the book as a whole is well illustrated with informative diagrams, figures and plates.

The economic aspects of the use of lightweight concrete as compared with the more traditional materials are concerned with the possibilities of reductions in initial costs, not only in regard to materials and labour in construction, but also due to lower unit weight, and in the case of buildings, in savings in heating costs by reason of improved thermal insulation.

Reduction in dead load is obtained when lightweight concrete is substituted for normal concrete in bridge decks, floors, roofs, fire protection to steelwork framing and in most varieties of partition and curtain walls. Thus, where employed in subsidiary portions of buildings, generally speaking the load bearing structure or frame together with the foundations would themselves need to be less substantial and a further saving in cost would result, which would be the more marked the higher the building. At the same time it would be a mistake to assume, unless comparative designs were prepared, that a saving in dead weight of any part of a structure necessarily implies a reduction in overall cost. As Mr. Whittaker remarks, "A better appreciation of the contribution which the lightweight concrete block can make towards building productivity is needed in Britain. and with it a development of the way of building best suited to the use of blocks. The British architect, builder, and block manufacturer will find guidance on many points from American experience."

The Report is published by Her Majesty's Stationery Office, London, at 4s. 6d. net (4s. 10d. post free).

H.F.C.

Sea Pollution by Oil

(continued from previous page)

Removal of Oil from Docks and other Enclosed Waters.

(21) The responsible authorities should take all possible steps to remove floating oil from docks and enclosed waters, so that it neither continues to pollute those waters nor finds its way out to adjacent waters. Similarly, dock or harbour or inland navigation authorities should do everything possible to remove concentrations of floating oil from tidal waters before the pollution becomes more widespread.

Amendment of the Oil in Navigable Waters Act, 1922.

(22) In addition to the amendments to the Oil in Navigable Waters Act, 1922, which will be necessary to give effect to the preventive measures referred to in the preceding recommendations, we recommend that the Act should be amended (a) to provide much more severe penalties: (b) to require the keeping of official records, either in the ship's log or otherwise, of the time and place of the discharge or disposal of any oil, including any mixture of water or other substance with oil (with the exception of discharges from machinery-space bilges); and any ballast water from tanks which have previously contained oil; and of the period of use of an oily-water separator, where fitted: (c) to apply the measures recommended for coastal vessels to vessels of foreign flag regularly employed in the coastal trade of the United Kingdom.

G. L. H. B.

Articles on the subject of Oil Pollution have already appeared in the June 1951 and August 1952 issues of The Dock and Harbour Authority.

Passenger Traffic at Port of Plymouth.

The Plymouth Chamber of Commerce are calling the attention of liner companies to the facilities available at Plymouth as a liner port of call. The Chamber suggest that in the national interest it is desirable that Plymouth should be maintained as a passenger port, so that the necessary facilities should be available in case of an emergency. They point out that it is impossible for any port to maintain reasonable efficiency unless it has sufficient support from steamship companies, and if the tenders are to be retained at Plymouth, and a sufficient labour force maintained, it is necessary for the passenger traffic of the port to be increased. Many lines which formerly used the port have not resumed their connection with Plymouth since the war. The port is capable of handling expeditiously large numbers of passengers, as was instanced by the call of the "Queen Mary" during the strike at Southampton, when she disembarked about 1,000 passengers. Recently the "Liberte" disembarked nearly 300 passengers and 5,000 bags of mail, and resumed her voyage three hours after anchoring. Since the war the reception hall at the docks has been reconstructed and modern passenger facilities are available, so that even when dealing with large numbers the boat trains are able to leave usually within an hour of disembarkation.

Wide Angle Berthing Gear

Energy Absorption of Vessels Berthing Angularly alongside Jetties, Piers and Wharves

By A. P. FITZJOHN, M.I.Mech.E.

While there are several efficient and satisfactory systems for absorbing the kinetic energy of vessels berthing broadside on, i.e. at right angles to the face of a jetty, it is freely admitted by engineers, indeed it is a complaint by many, that there is not a really good solution to the problem of dealing with glancing blows by vessels when approaching a berth. It is likewise acknowledged that glancing blows are much more frequent, heavier and consequently more damaging than direct-on or right angle impacts; this is evidenced by the number of fender piles that are broken or stressed beyond their elastic limit, thereby taking a " permanent set " and leaning so much beyond their original vertical position as to render them useless for their purpose.

In order to solve this problem, particularly in regard to open piled and slab construction jetties having supplementary fender piles, a wide angle berthing gear comprising an arrangement of levers controlled by really high energy absorption buffer units has now been accomplished.

The gear illustrated in Fig. 1 is designed to restrain and limit the movement inwardly and laterally of fender piles and to absorb the energy of ships when berthing through an angle of approximately 180 degrees. It consists of a horizontal fender beam carrying a pair of fender yokes, connected by links or connecting rods to two pairs of energy absorbing units disposed right hand and left hand which is bolted to the jetty deck. Each unit comprises a rigid bedplate on which are mounted two high capacity hydro-pneumatic buffers and a large diameter pivot shaft carrying two crank levers. The buffers are mounted on the bedplates with their heads directed away from the fender beam, and each buffer is connected to its representative crank lever by the means of tierods from the buffer head, through a cross head and connecting rod. The opposite end of the lever composite with the outside buffer is joined to the beam yoke adjacent to the unit by a connecting rod, and the inside buffer is connected through its respective lever by a connecting rod adjustable lengthwise to the beam yoke of the opposite hand unit.

The horizontal fender beam may be positioned between the fender piles and the berthing vessels, or between the piles and the face of the jetty, but in either case the fender piles should be guided or secured to the fender beam for control of lateral movement.

In use, movement of the fender beam and piles in any direction is restrained by the buffers. The outside buffers absorb the energy of direct-on impacts, and those mounted inside absorb lateral and acute angle impacts. The buffers are so mounted and arranged that they operate independently or conjointly according to the angle and point of contact.

All the buffer plungers operate inwardly under a pulling action applied thereto through the connecting rods and levers by inward and/or lateral movement of the fender beam. The extent of stroke of the buffers, which can be predeterminedly arranged or adjusted, determines the maximum amount of shock absorbing movement of the fender beam and fender piles. By connecting the upper ends of the fender piles to the fender beam, movement of the said piles is limited and thereby prevents their being overstressed and taking a permanent set or deflection.

With regard to energy absorption, the characteristics of hydro-pneumatic buffers are described later, but taking as example: a gear as referred to having four buffers, each of 12-in. stroke and having a designed energy absorption capacity of 100-ft. tons at an impact speed of 1-ft. per second; then the capacity for approximately a direct-on impact equals 2 outside buffers at 12-in. stroke and 2 inside buffers at 2-in. stroke $= (2 \times 100) + (2 \times 16) = 232$-ft. tons total, to which should be added the potential energy in the fender piles against deflection. Ships, however, when berthing, seldom approach broadside on, but more often at an acute angle of 10 to 15 degrees to the line of the jetty, and in these cases the fender piles have to withstand heavy lateral thrust with little inward movement. The gear restrains the lateral movement of the fender piles, and limits the movement at the top to that of the stroke in the buffer, in so doing one of the inside buffers according to the direction of approach absorbs 100-ft. tons energy to which must also be added the potential energy in the fender piles. Thus the piles are enabled to ride impacting blows.

With regard to the connecting rods, as the buffers with their respective bell crank levers and pivot shaft, are mounted on an accurately dimensioned bedplate, the connecting rod centres are determined with mechanical accuracy with no lost motion but the provision for adjustment of the crossheads on the buffer tierods ensures tension on all connecting members equal to the initial load in the buffers when the fender beam is in the free or static position. The long rods connecting the R.H. unit to the L.H. beam yoke, and the L.H. unit to the R.H. beam yoke, are in two parts joined together by heavy turnbuckles to effect adjustment. All the connecting rods operate in tension, and no compression or bending stresses are incurred.

Ships frequently sustain damage when passing through the entrance channels to docks, especially when the clearance between the beam width of the ship and the width of the channel is limited. In many cases the entrance and the exit knuckles are faced with timber walings and rope fenders but these do not provide the full answer to the problem of preventing damage to the ship hulls; moreover, they usually further restrict the width of the channel, thereby aggravating the conditions. The gear described can also be effectively applied to radiused fenders as small as 10 to 12-ft. radius and to operate at water levels varying as much as 6-ft. The knuckle

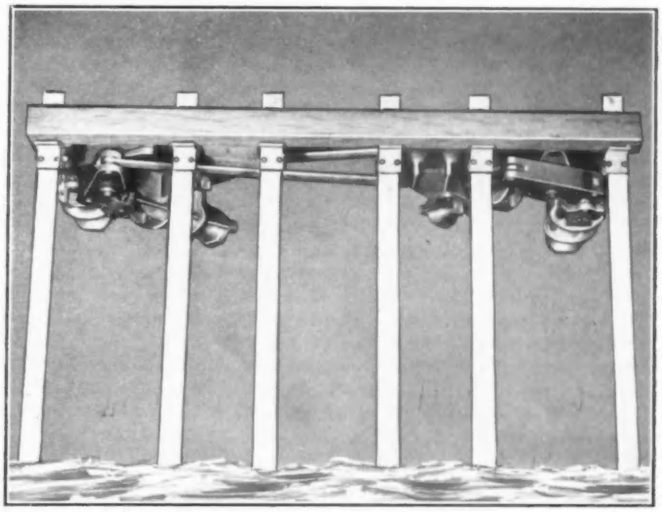


Fig. 1.

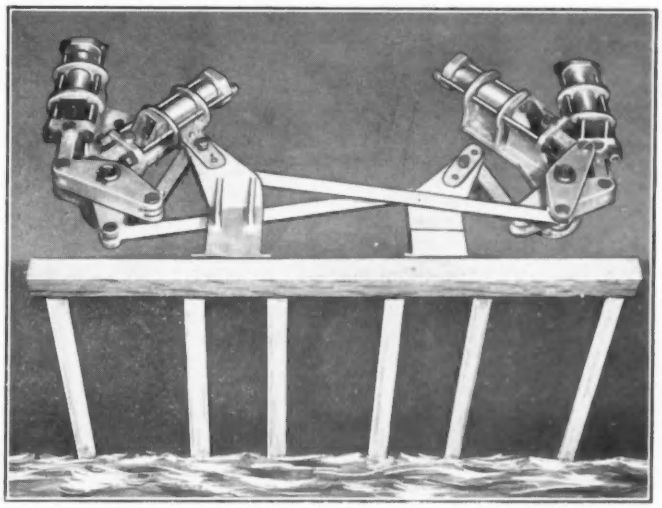


Fig. 1a. Illustrates the gear inverted.

Wide Angle Berthing Gear—continued

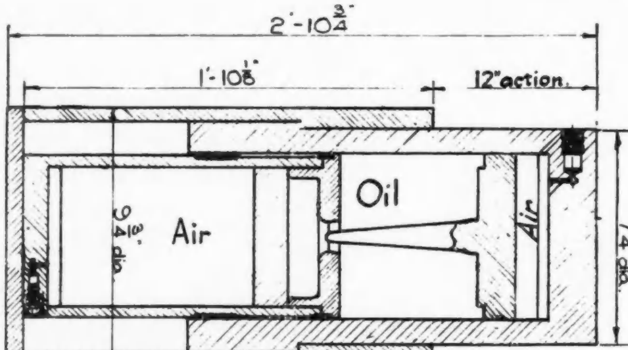


Fig. 2. Hydro-Pneumatic Buffer.

fenders may be mounted in such a manner that the full inward movement of the fender maintains the maximum width of the entrance channel and to ride with restraint in the direction of the ship a distance equal to the stroke of the buffers.

Fig. 2 shows the type of hydro pneumatic buffers employed in the gear. This buffer is speed sensitive and its energy absorption capacity is automatically variable from zero to 100-ft. tons in 12-in. of stroke, depending upon the weight of the vessel and speed at impact. The initial impact is taken on the pneumatic or air cushion immediately behind the buffer head and between the floating piston carrying the throttle stem, thereby increasing the pressure on the hydraulic oil and inducing its flow through the restricted orifice into the displacement chamber behind the internal cylinder head. There is a critical point relative to speed of impact and area of orifice at which a return power wave occurs, due to the incompressibility of the oil and resistance to flow through the orifice, and to eliminate or dampen out the return power wave the air cushion is introduced.

The buffer is charged with oil and air to a determined pressure ready for service, say 1 ton initial load at which the floating piston carrying the throttle stem and operating oil is held in a balanced position by opposing differential air pressures i.e. the air cushion at the head end of the plunger cylinder and the air under pressure behind the floating piston in the buffing cylinder. As the rate of discharge of the oil from the plunger cylinder into the buffing cylinder is proportionate to the area of the orifice formed by the

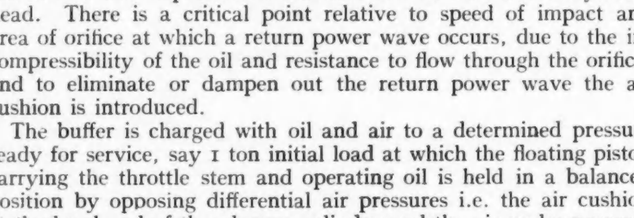


Fig. 3. Energy and Load at 3-in. per sec.

throttle stem, it will be appreciated that if the designed area of the orifice is sufficient to permit a freely balanced flow of oil into the buffing cylinder at say 3-in. per second, the energy will be absorbed pneumatically in the air chambers, approximately 6 ft. tons. If however, the speed is greater than 3-in. per second a resistance to the flow of the oil proportional to the square of the increase in speed will be set up causing a build up of pressure in the main cylinder, thereby absorbing energy additional to that in compressing the air.

Recoil or return of the buffer plunger to the extended position upon release of the load is effected by the air expansion in the buffing cylinder. The air compressed in this cylinder is not free to expand explosively as the expansion is resisted by the piston having to return the oil through the throttled orifice to the plunger cylinder also against the pressure in the air cushion. Hence the energy of the recoil is only fractional of the input energy.

Figs. 3 and 4 show the comparison of energy absorption at impact speeds of 3 and 10-in. per second respectively. The capacity for energy absorption would increase with greater speed of impact up to the stalling point of flow through the orifice.

Both the air and the oil are positively separated from each other

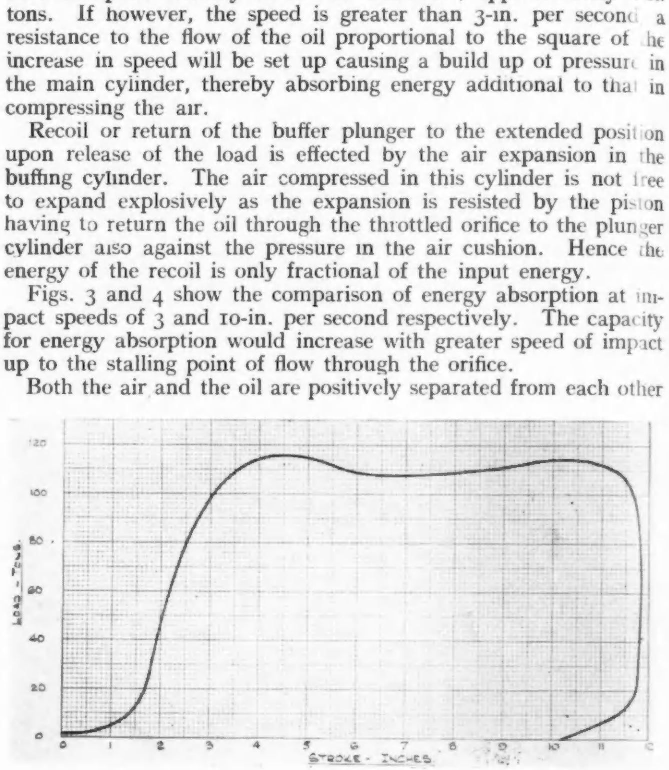


Fig. 4. Load at 10-in. per sec.
Energy is equal to scaled area under curve.

by automatic pressure balanced seals.* The piston members are made of specially manufactured non-metallic material, possessing many times the wearing properties of high quality bronze, which is non porous and being non-metallic prevents scoring or scuffing of the precision honed cylinder bores, so ensuring almost infinite life of the cylinders.

The fact that fender buffers and equipment are subject to immersion in sea water has not been disregarded, an efficient system is in service whereby the buffers are sealed against the ingress of water and is arranged for lubrication at high pressure from a central point at deck level. Also to eliminate excessive wear in the connecting rod and pivot bearings, these are bushed with phenolformaldehyde plastic, oil stabilized, resistant to and self lubricating in water. This type of plastic has superseded lignum and bronzes for Stern Tube and other bearings operating in sea water where lubrication by water is essential. In order to prevent corrosion and to counteract marine growths, the buffers, levers and connecting rods are "phosphated" before the first coat of priming paint and finally sprayed with copper sulphate compound.

Development Grant for the Port of Limerick.

A scheme for the extension and modernisation of the Port of Limerick which has been in abeyance mainly for financial reasons, may be started this year with increased Government assistance. The scheme involves the expenditure of an estimated £350,000 on dredging and dock installations over a period of three years and the purchase of a new dredger at an estimated cost of £100,000.

The Minister for Industry and Commerce, Eire, in a letter to the Harbour Board, offered to contribute £225,000 towards the cost instead of about £150,000 promised two years ago and regarded by the Board as inadequate. The increased assistance will be made available on condition that the Board increase port dues and purchase a new dredger instead of the secondhand plant for which they had been negotiating for economy reasons.

The Royal River Pageant

The Port of London celebrates the Coronation

By A. G. THOMPSON.

On 22nd July Her Majesty the Queen, accompanied by His Royal Highness the Duke of Edinburgh, witnessed a River Pageant on the Thames held to mark the Coronation, and in recognition of the importance of the River Thames to the capital city and the nation.

The head of the procession, which was three miles long, left Greenwich at 10.00 hours and proceeded up-river at a speed of four knots, passing by Her Majesty from 11.30 hours onwards. The procession which consisted of seven sections was preceded by the Chief Harbour Master of the Port of London Authority, Elder Brethren of Trinity House, and Officers of the Thames Division of the Metropolitan Police.

Her Majesty came by road to the Royal Festival Hall and thence walked down the pier approach which was lined by Royal Watermen who provided a guard of honour. Music was played by the London Fire Brigade Band, one of whose Fire Floats, the "Massey Shaw," took part in the procession. This famous vessel took part in the evacuation from Dunkirk and even on this Royal occasion was "on duty" and in communication by R/T with shore headquarters should there have been a fire on the river.

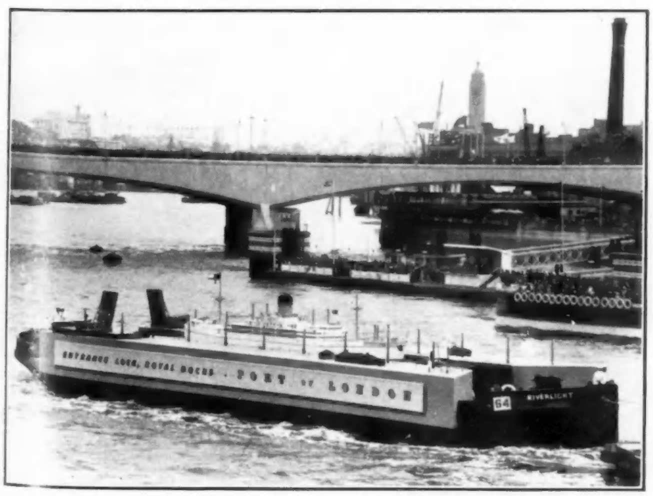
The first section of the Pageant was the Lord Mayor's Procession and as was fitting the Lord Mayor who has the ancient title of Admiral of the Port was escorted by Mayors of Riverside Boroughs and by Liverymen of the great City Guilds which throughout the centuries have contributed so much to the development of London's commerce and trade.

Services of the Crown using the port was represented by fast patrol boats of the Royal Navy, Landing Craft Assault, manned by Royal Marine Commandoes and launches manned by Mine Watching personnel—a newly formed service. The Army was represented by launches of the Royal Army Service Corps, the Inland Water Transport (Royal Engineers), while the Royal Air Force manned Target Search and Air-Sea Rescue launches. Port services included a Trinity House Pilot Cutter, Customs launches, the Port Authority's salvage vessel "Glengall," various types of tugs, canal narrow boats, the Southend-on-Sea lifeboat and a Missions to Seamen launch. Decca Navigation and Marconi Radar Navigation were also included.

For the first time for centuries the flag of St. John of Jerusalem was seen on the Thames flying from a launch carrying members of the Port of London Authority's newly formed division.

The Merchant Navy was represented by ships' lifeboats flying the flags of their respective lines, a motor tanker, and cadets from the Thames Nautical Training School. Sea Cadets provided one of the bands, and five groups of Sea Scouts were afloat.

The historical section consisted of twelve tableaux mounted on



Port of London Exhibit passing H.M. Queen Elizabeth II on Festival Hall Pier.

Procession of small craft in Kings Reach, with St. Pauls and the City of London in background.

lighters towed by tugs, among the items portrayed being Royal Marines showing the change in their costume from 1664 to date. Thames Watermen who had won the Doggetts Coat and Badge formed another tableau looking resplendent in their orange-red liveries. "Famous Victorians" included Isambard Brunell, the designer and builder of the famous "Great Eastern" which had twin screws, paddles and sails. Following the tableaux was Thornycroft's "Waterlily," built in 1867 and still in use. Abreast of the "Waterlily" was the "Chowkedar," a steam pinnance which was used by the River Police from 1884 to 1915.

Industry and Commerce were represented on decorated barges with tableaux and included Australia and New Zealand, coal, timber, furs, oil, tea, grain and refrigerated produce. Wharfingers staged a contrast between an early Legal Quay and a Modern Wharf, while the Port of London Authority's exhibit was a 144-ft. long barge on which was a model of the "Gothic"—the ship in which H.M. The Queen and H.R.H. The Duke of Edinburgh are sailing to Australia and New Zealand. This model ship, 56-ft. long, was in a model of the entrance lock to the King George V Dock, complete with lock gates and bascule bridge.

Finally nearly forty private craft, yachts, cabin cruisers, etc., brought up the rear of the Pageant, and included in this flotilla were the "Lazy Days," "Maaslust" and "Wolsey" which had taken part in the evacuation from Dunkirk. In the procession were ten bands, and an orchestra conducted by "George Frederick Handel" playing appropriate Water Music.

The Pageant was enthusiastically received by a vast crowd which lined the banks of the river for seven miles. It was London River day. Grey skies and heavy showers of rain did not deter Londoners from coming to the riverside, and they were not disappointed for never before has the "liquid history" of the Thames been illustrated so vividly. It was a day that will long be remembered, a day on which the thousands of school-children who witnessed the Pageant learnt more of the history of this great port than ever they were likely to come across in a school text book. Adult citizens of London who witnessed the procession realised, perhaps for the first time, the ramifications and many services of the modern but ancient Port of London.

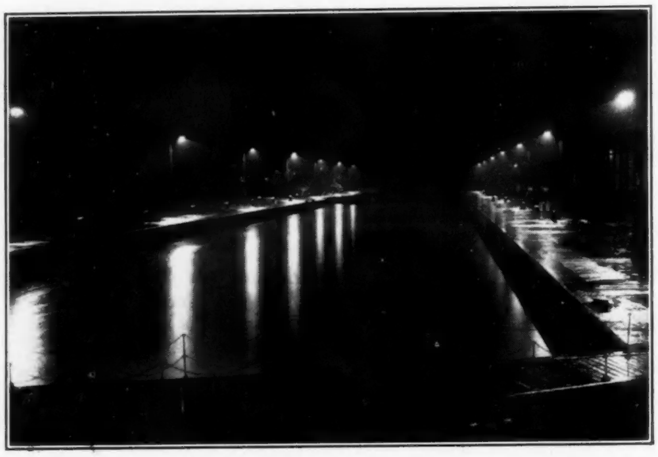
New Berthing Basin at Port of Alexandria.

A new basin for berthing oil tankers in the Port of Alexandria, Egypt, is expected to be in use shortly. This basin is claimed to be one of the largest of its kind in the world, measuring about 980-ft. in length by 1,300-ft. in width. It can accommodate five large tankers at the one time and the cost of construction has totalled approximately £E750,000. Work will begin soon on the second part of the project, the building of the oil storage depots which will be leased to the major oil companies. New quays for the discharge of fertilizers at Alexandria are expected to be completed this year. The total length of the quays will be about 1,500-ft., with berths for six vessels.

Manufacturers' Announcements

Floodlighting at the Port of London Authority

The accompanying photograph shows the floodlighting installation at the King George V Dock, London, to facilitate the movement of shipping at night. Duoflux Floodlights were used and the installation is of particular interest due to the following special requirements: Firstly, good definition of quayside: Secondly, freedom from glare to the River Pilots on ships' bridges guiding the ships to and from berths: Thirdly, the floodlight fittings were required to be mounted on existing steel lattice towers.



Thirty Duoflux units were used, each having 1,000 watt lamps. Each floodlight, which is mounted 28-ft. 6-in. above the quayside, consists of two reflectors, the main reflector of heavy gauge pressed steel, finished with " Crysteel " vitreous enamel, being in a shovel shape directing the light forwards and downwards, while the auxiliary reflector of Brytal anodised aluminium is mounted inside this, behind the lamp, so as to give increased distance to the light throw.

The lock entrance is 800-ft. long and 100-ft. wide (water area) whilst if the width of the bounding quays is taken into consideration, the total width to illuminate is around 250-ft. Ships of up to 36,000 tons can pass through the lock, the s.s. " Mauretania " having done so on her maiden voyage in 1939.

The installation was planned by The Benjamin Electric Ltd., in conjunction with the Port of London Authority Engineers and installed by Electrical Installations, Ltd.

Detection of Corrosion by Radiography

A new technique in marine engineering has been evolved in combatting corrosion. This is the use of radiography (industrial " X-raying ") with isotopes to detect possible corrosion in steel dock piers.

Saguenay Terminals, Ltd., operating a $3,000,000 wharf at Port Alfred, Lake Superior, Canada, suspected that salt in the water and industrial waste might be causing corrosion of the steel piles on which the wharf is built. It was decided to send down a diver, but the murky water and waste deposits on the piling made examination impossible. Aluminium Laboratories were called in and they in turn consulted Isotope Products who had already conducted experiments with " X-rays " to deal with this kind of problem. A further series of tests were carried out and these proved so successful that it was decided to proceed with the main project.

Three experts from the two companies, Aluminium Laboratories and Isotope Products, undertook the underwater examination using special equipment designed jointly by the two concerns. Using two rowing boats, the scientists lowered a specially constructed carriage which supported film on three sides of the piles and an isotope source of iridium 192.

The isotope capsule was secured to a lead base and covered by a removable lead cover. The unit weighed approximately 20 pounds. One metal cable controlled the entire unit: another cable raised and lowered the castle cover to expose the source and contain it. X-ray film was heat-sealed (in the boat) into plastic water-proof envelopes and supported on the wheeled carriage designed to travel up and down the 14-in. H-piles that supported the wharf. The H-piles are of half-inch steel construction. The X-ray film was thus rolled down three sides of the pile while the isotope source was exposed from another side to record the film.

Samples were taken every 6-ft. down the underwater depth of seven piles selected at random. Approximately 50 exposures were made in about eight hours, under " only fair " weather conditions. The films confirmed the safety of the piles and exactly determined the amount of corrosion where it was encountered.

A Handbook on Marine Paints.

The Marine Division of British Paints, Ltd., has published a second edition of the " Marine Handbook," a 66-page illustrated brochure intended as a guide to the selection and application of the correct paint under the best possible conditions. Separate sections are devoted to the painting of ships' bottoms, hulls, exteriors, holds and 'tween decks, and there are two sections devoted to newbuildings, one dealing with vessels in general and the other with tankers. The marine paints produced by the company are detailed and their uses specified.